

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



21

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : C08F 10/00, 4/70, 4/82, C07F 15/04, C07D 207/335, C07C 225/14, 229/30, 237/16, 327/44		A1	(11) International Publication Number: WO 98/30609 (43) International Publication Date: 16 July 1998 (16.07.98)
(21) International Application Number: PCT/US98/00610 (22) International Filing Date: 13 January 1998 (13.01.98) (30) Priority Data: 60/035,190 14 January 1997 (14.01.97) US (71) Applicant (for all designated States except US): E.I. DU PONT DE NEMOURS AND COMPANY [US/US]; 1007 Market Street, Wilmington, DE 19898 (US). (72) Inventors; and (75) Inventors/Applicants (for US only): JOHNSON, Lynda, Kaye [US/US]; Apartment 5B2, 402 Foulk Road, Wilmington, DE 19803 (US). BENNETT, Alison, Margaret, Anne [US/US]; 507 Falkirk Road, Wilmington, DE 19803 (US). ITTEL, Steven, Dale [US/US]; 2802 Landon Drive, Wilmington, DE 19810 (US). WANG, Lin [CN/US]; 112 Brook Run, Hockessin, DE 19707 (US). PARTHASARATHY, Anju [US/US]; 1562 Pottstown Pike, Glenmoore, PA 19343 (US). HAUPTMAN, Elisabeth [FR/US]; 2106-B Haven Road, Wilmington, DE 19809 (US). SIMPSON, Robert, D. [US/US]; 707 Westview Avenue, Philadelphia, PA 19119 (US). FELDMAN, Jerald [US/US]; 16 Cinnamon Drive, Hockessin, DE 19707 (US). COUGHLIN, Edward, Bryan		(74) Agent: EVANS, Craig, H.; E.I. du Pont de Nemours and Company, Legal Patent Records Center, 1007 Market Street, Wilmington, DE 19898 (US). (81) Designated States: AL, AM, AU, AZ, BA, BB, BG, BR, BY, CA, CN, CU, CZ, EE, GE, GW, HU, ID, IL, IS, JP, KG, KP, KR, KZ, LC, LK, LR, LT, LV, MD, MG, MK, MN, MX, NO, NZ, PL, RO, RU, SG, SI, SK, SL, TJ, TM, TR, TT, UA, US, UZ, VN, YU, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>	
(54) Title: POLYMERIZATION OF OLEFINS			
(57) Abstract <p>Selected olefins such as ethylene and α-olefins are polymerized by nickel [II] complexes of certain monoanionic ligands. The polyolefins are useful in many applications such as molding resins, film, fibers and others. Also described are many novel nickel compounds and their precursors, as well as novel ligands.</p>			

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

TITLE

POLYMERIZATION OF OLEFINS

This application claims the benefit of U.S.
5 Provisional Application No. 60/035,190, filed
January 14, 1997.

FIELD OF THE INVENTION

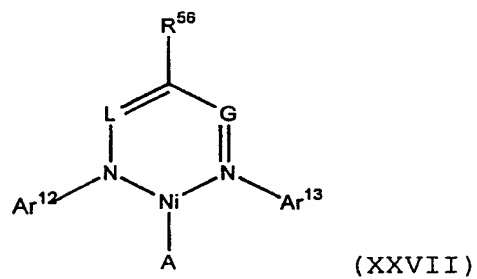
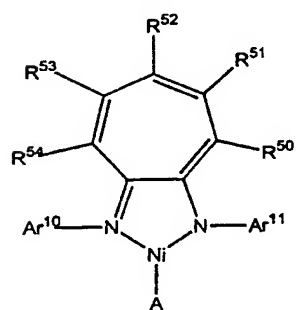
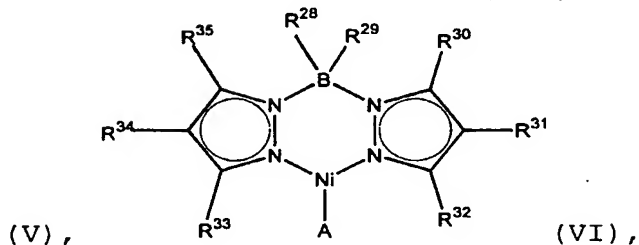
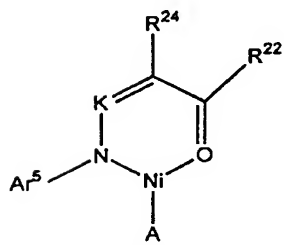
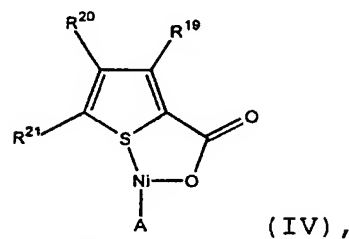
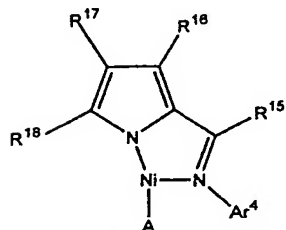
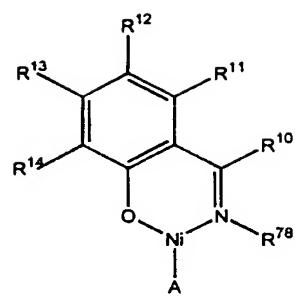
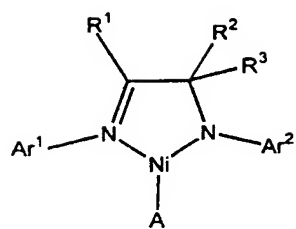
Olefins are polymerized by a catalyst system that
10 includes a nickel[II] complexes of selected monoanionic
bidentate ligands. Some of these complexes are also
novel.

TECHNICAL BACKGROUND

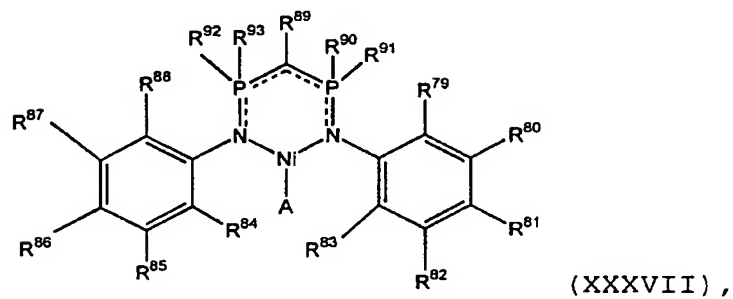
Polymers of ethylene and other olefins are
15 important items of commerce, and these polymers are
used in a myriad of ways, from low molecular weight
polyolefins being used as a lubricant and in waxes, to
higher molecular weight grades being used for fiber,
films, molding resins, elastomers, etc. In most cases,
20 olefins are polymerized using a catalyst, often a
transition metal compound or complex. These catalysts
vary in cost per unit weight of polymer produced, the
structure of the polymer produced, the possible need to
remove the catalyst from the polyolefin, the toxicity
25 of the catalyst, etc. Due to the commercial importance
of polymerizing olefins, new polymerization catalysts
are constantly being sought.

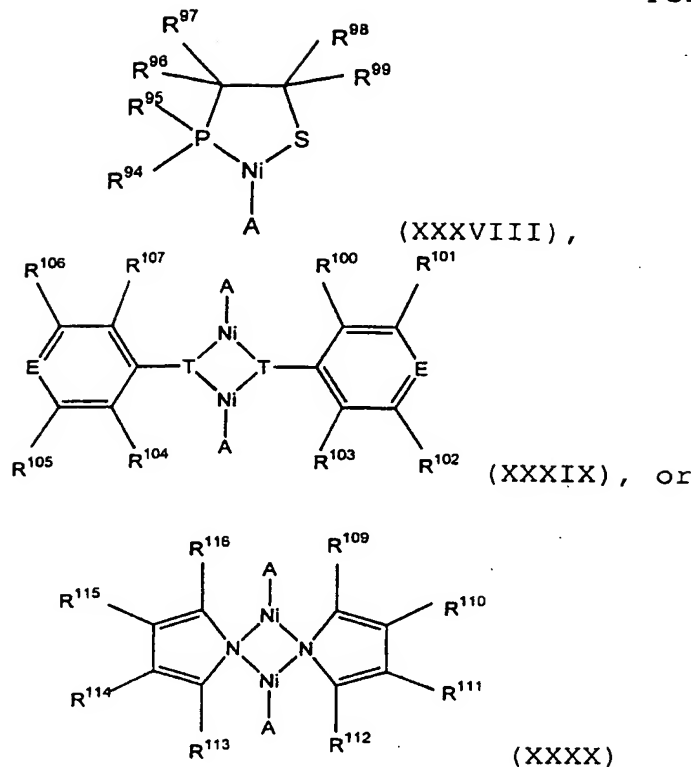
SUMMARY OF THE INVENTION

This invention concerns a process for the
30 polymerization of an olefin selected from one or more
of $R^{67}CH=CH_2$, cyclopentene, a styrene, a norbornene or
 $H_2C=CH(CH_2)_sCO_2R^{77}$, comprising, contacting, at a
temperature of about $-100^\circ C$ to about $+200^\circ C$, $R^{67}CH=CH_2$,
cyclopentene, a styrene, a norbornene, or
35 $H_2C=CH(CH_2)_sCO_2R^{77}$, optionally a Lewis acid, and a
compound of the formula:



5





5

wherein:

Ar¹, Ar², Ar⁴, Ar⁵, Ar¹⁰, Ar¹¹, Ar¹² and Ar¹³
are each independently aryl or substituted aryl;

R¹ and R² are each independently hydrogen,
10 hydrocarbyl, substituted hydrocarbyl, or R¹ and R²
taken together form a ring, and R³ is hydrogen,
hydrocarbyl or substituted hydrocarbyl or R¹, R² and R³
taken together form a ring;

A is a π -allyl or π -benzyl group;

15 R¹⁰ and R¹⁵ are each independently hydrogen,
hydrocarbyl or substituted hydrocarbyl;

R¹¹, R¹², R¹³, R¹⁴, R¹⁶, R¹⁷, R¹⁸, R¹⁹, R²⁰,
R²¹, R³⁰, R³¹, R³², R³³, R³⁴, R³⁵, R⁵⁰, R⁵¹, R⁵², R⁵³
and R⁵⁴ are each independently hydrogen, hydrocarbyl,
20 substituted hydrocarbyl, an inert functional group, and
provided that any two of these groups vicinal to one
another taken together may form a ring;

K is N or CR²⁷;

R^{22} is hydrocarbyl, substituted hydrocarbyl, $-SR^{117}$, $-OR^{117}$, or $-NR^{118}_2$, R^{24} is hydrogen, a functional group, hydrocarbyl or substituted hydrocarbyl, and R^{27} is hydrocarbyl or substituted hydrocarbyl, and provided
5 that R^{22} and R^{24} or R^{24} and R^{27} taken together may form a ring;

R^{117} is hydrocarbyl or substituted hydrocarbyl;
each R^{118} is independently hydrogen, hydrocarbyl or substituted hydrocarbyl;

10 G and L are both N or G is CR^{57} and L is CR^{55} ;
 R^{55} , R^{56} and R^{57} are each independently hydrogen, hydrocarbyl or substituted hydrocarbyl, or any two of R^{55} , R^{56} and R^{57} taken together form a ring;

R^{67} is hydrogen, alkyl or substituted alkyl;
15 R^{77} is hydrocarbyl or substituted hydrocarbyl;
 R^{78} is hydrocarbyl or substituted hydrocarbyl;
 R^{79} , R^{80} , R^{81} , R^{82} , R^{83} , R^{84} , R^{85} , R^{86} , R^{87} , R^{88} and R^{89} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or a functional group;

20 R^{90} , R^{91} , R^{92} and R^{93} are each independently hydrocarbyl or substituted hydrocarbyl;

R^{94} and R^{95} are each independently hydrocarbyl or substituted hydrocarbyl;

R^{96} , R^{97} , R^{98} , and R^{99} are each independently
25 hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group;

both of T are S (sulfur) or NH (amino);

each E is N (nitrogen) or CR^{108} wherein R^{108} is hydrogen, hydrocarbyl, substituted hydrocarbyl or a
30 functional group;

R^{100} , R^{101} , R^{102} , R^{103} , R^{104} , R^{105} , R^{106} , and R^{107} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or a functional group;

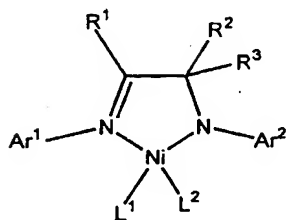
R^{109} , R^{110} , R^{111} , R^{112} , R^{113} , R^{114} , R^{115} and R^{116} are
35 each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group;

s is an integer of 1 or more; and

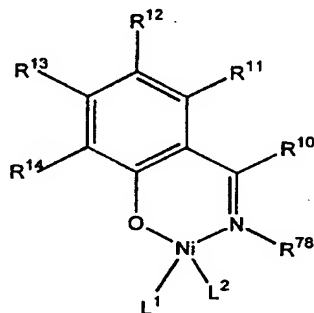
R^{28} and R^{29} are each independently hydrogen, hydrocarbyl or substituted hydrocarbyl;

and provided that when $H_2C=CH(CH_2)_5CO_2R^{77}$ is present, $R^{67}CH=CH_2$ is also present.

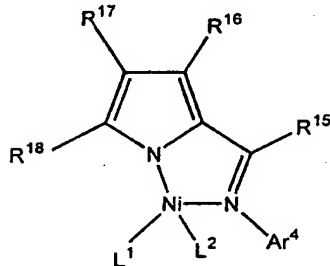
- 5 This invention also concerns a process for the polymerization of an olefin selected from one or more of $R^{67}CH=CH_2$, a styrene, a norbornene or $H_2C=CH(CH_2)_5CO_2R^{77}$, comprising, contacting, at a temperature of about $-100^\circ C$ to about $+200^\circ C$, $R^{67}CH=CH_2$,
 10 cyclopentene, a styrene, a norbornene, or $H_2C=CH(CH_2)_5CO_2R^{77}$, optionally a Lewis acid, and a compound of the formula:



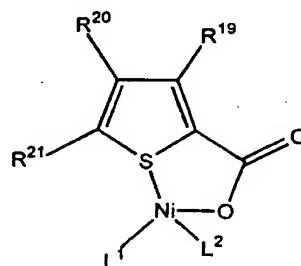
(VII),



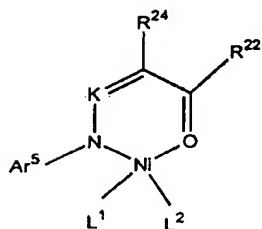
(VIII),



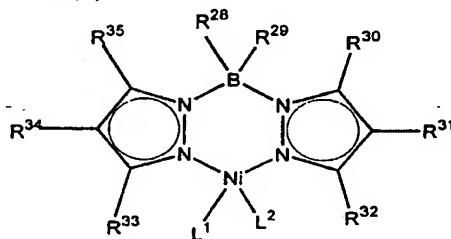
(IX),



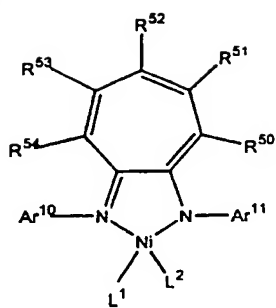
(X),



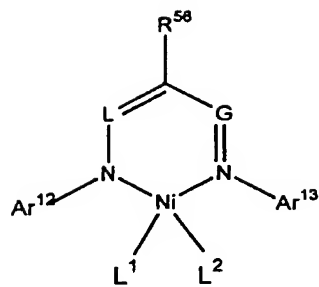
(XI),



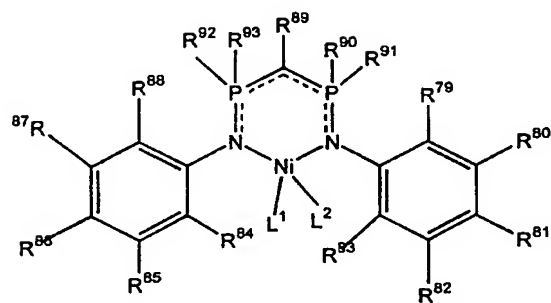
(XII),



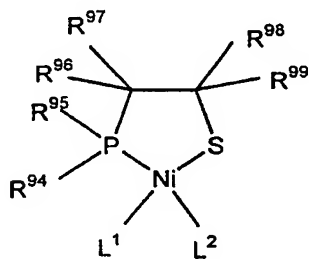
(XIX),



(XXVIII)

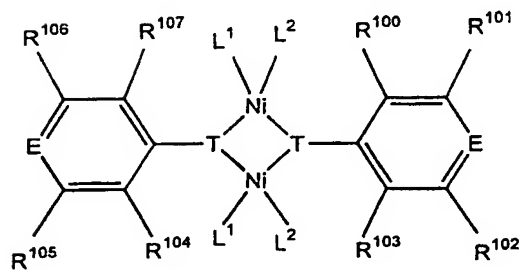


(XXXXI),

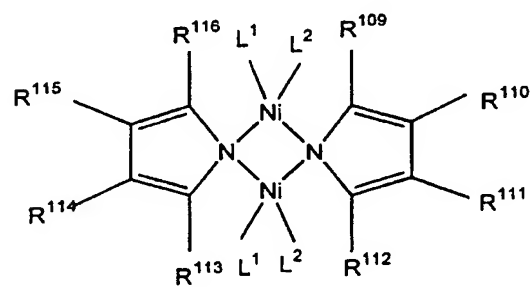


(XXXXII),

5



(XXXXIII), or



(XXXXIV),

wherein:

L^1 is a neutral monodentate ligand which may be displaced by said olefin, and L^2 is a monoanionic monodentate ligand, or L^1 and L^2 taken together are a
 5 monoanionic bidentate ligand, provided that said monoanionic monodentate ligand or said monoanionic bidentate ligand may add to said olefin;

Ar^1 , Ar^2 , Ar^4 , Ar^5 , Ar^{10} , Ar^{11} , Ar^{12} and Ar^{13} are each independently aryl or substituted aryl;
 10 R^1 and R^2 are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or R^1 and R^2 taken together form a ring, and R^3 is hydrogen, hydrocarbyl or substituted hydrocarbyl or R^1 , R^2 and R^3 taken together form a ring;

15 R^{10} and R^{15} are each independently hydrogen, hydrocarbyl or substituted hydrocarbyl;
 R^{11} , R^{12} , R^{13} , R^{14} , R^{16} , R^{17} , R^{18} , R^{19} , R^{20} , R^{21} , R^{30} , R^{31} , R^{32} , R^{33} , R^{34} , R^{35} , R^{50} , R^{51} , R^{52} , R^{53} and R^{54} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, an inert functional group, and
 20 provided that any two of these groups vicinal to one another taken together may form a ring;

K is N or CR^{27} ;
 R^{22} is hydrocarbyl, substituted hydrocarbyl,
 25 $-SR^{117}$, $-OR^{117}$, or $-NR^{118}_2$, R^{24} is hydrogen, a functional group, hydrocarbyl or substituted hydrocarbyl, and R^{27} is hydrocarbyl or substituted hydrocarbyl, and provided that R^{22} and R^{24} or R^{24} and R^{27} taken together may form a ring;

30 R^{117} is hydrocarbyl or substituted hydrocarbyl;
 each R^{118} is independently hydrogen, hydrocarbyl or substituted hydrocarbyl;

G and L are both N or G is CR^{57} and L is CR^{55} ;
 R^{55} , R^{56} and R^{57} are each independently
 35 hydrogen, hydrocarbyl or substituted hydrocarbyl, or any two of R^{55} , R^{56} and R^{57} taken together form a ring;
 R^{67} is hydrogen, alkyl or substituted alkyl;
 R^{77} is hydrocarbyl or substituted hydrocarbyl;

R^{78} is hydrocarbyl or substituted hydrocarbyl;
 R^{79} , R^{80} , R^{81} , R^{82} , R^{83} , R^{84} , R^{85} , R^{86} , R^{87} , R^{88} and R^{89} are
 each independently hydrogen, hydrocarbyl, substituted
 hydrocarbyl, or a functional group;

5 R^{90} , R^{91} , R^{92} and R^{93} are each independently
 hydrocarbyl or substituted hydrocarbyl;

R^{94} and R^{95} are each independently hydrocarbyl
 or substituted hydrocarbyl;

10 R^{96} , R^{97} , R^{98} , and R^{99} are each independently
 hydrogen, hydrocarbyl, substituted hydrocarbyl or a
 functional group;

both of T are S (sulfur) or NH (amino);

each E is N (nitrogen) or CR^{108} wherein R^{108} is
 hydrogen, hydrocarbyl, substituted hydrocarbyl or a
 15 functional group;

R^{100} , R^{101} , R^{102} , R^{103} , R^{104} , R^{105} , R^{106} , and R^{107} are
 each independently hydrogen, hydrocarbyl, substituted
 hydrocarbyl, or a functional group;

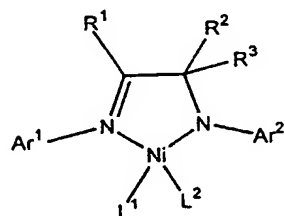
20 R^{109} , R^{110} , R^{111} , R^{112} , R^{113} , R^{114} , R^{115} and R^{116} are
 each independently hydrogen, hydrocarbyl, substituted
 hydrocarbyl or a functional group;

s is an integer of 1 or more; and

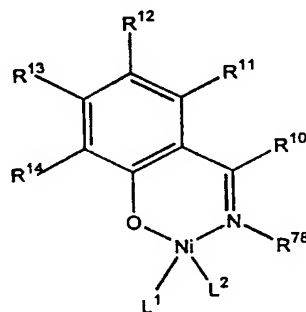
R^{28} and R^{29} are each independently hydrogen,
 hydrocarbyl or substituted hydrocarbyl;

25 and provided that when $H_2C=CH(CH_2)_sCO_2R^{77}$ is
 present, $R^{67}CH=CH_2$ is also present.

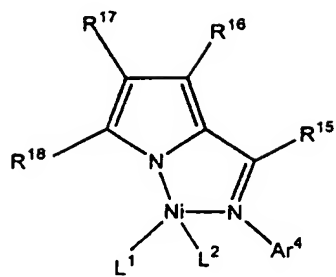
Also described herein is a compound of the
 formula:



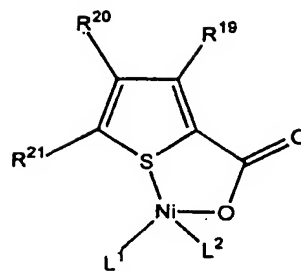
(VII),



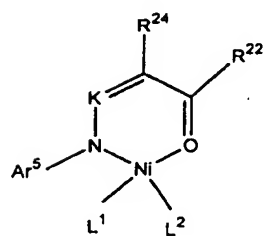
(VIII),



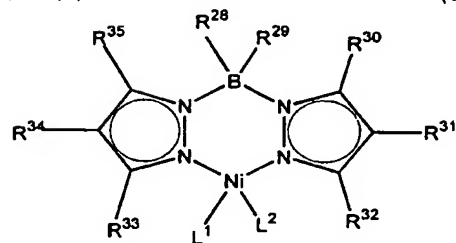
(IX),



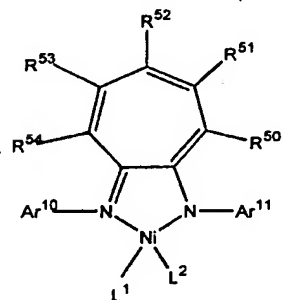
(X),



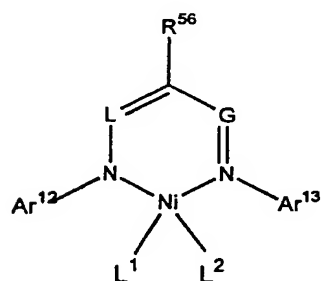
(XI), or



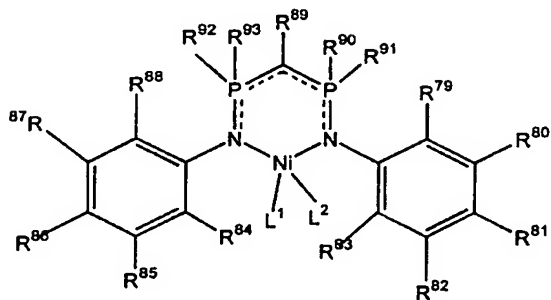
(XII),



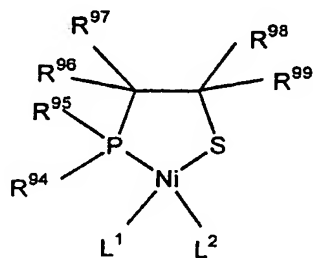
(XIX),



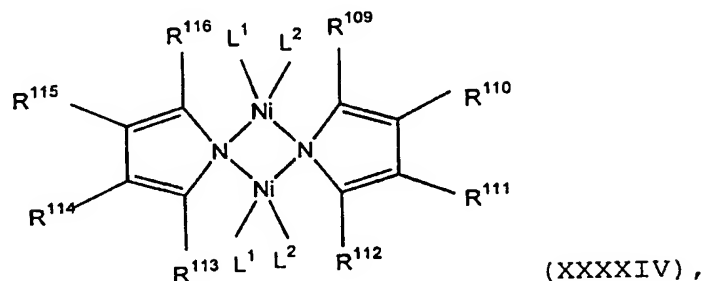
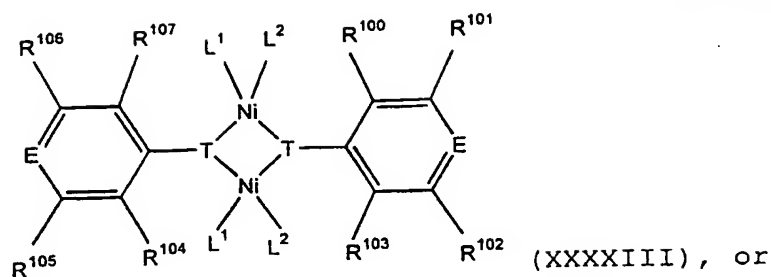
(XXVIII)



(XXXXI),



(XXXXII),



wherein:

5 L^1 is a neutral monodentate ligand which may be displaced by said olefin, and L^2 is a monoanionic monodentate ligand, or L^1 and L^2 taken together are a monoanionic bidentate ligand, provided that said monoanionic monodentate ligand or said monoanionic bidentate ligand may add to said olefin;

10 $Ar^1, Ar^2, Ar^4, Ar^5, Ar^{10}, Ar^{11}, Ar^{12}$ and Ar^{13} are each independently aryl or substituted aryl;

R^1 and R^2 are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or R^1 and R^2 taken together form a ring, and R^3 is hydrogen, hydrocarbyl or substituted hydrocarbyl or R^1, R^2 and R^3 taken together form a ring;

R^{10} and R^{15} are each independently hydrogen, hydrocarbyl or substituted hydrocarbyl;

20 $R^{11}, R^{12}, R^{13}, R^{14}, R^{16}, R^{17}, R^{18}, R^{19}, R^{20}, R^{21}, R^{30}, R^{31}, R^{32}, R^{33}, R^{34}, R^{35}, R^{50}, R^{51}, R^{52}, R^{53}$ and R^{54} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, an inert functional group, and provided that any two of these groups vicinal to one

25 another taken together may form a ring;

K is N or CR^{27} ;

R^{22} is hydrocarbyl, substituted hydrocarbyl, $-SR^{117}$, $-OR^{117}$, or $-NR^{118}_2$, R^{24} is hydrogen, a functional group, hydrocarbyl or substituted hydrocarbyl, and R^{27} is hydrocarbyl or substituted hydrocarbyl, and provided
5 that R^{22} and R^{24} or R^{24} and R^{27} taken together may form a ring;

R^{117} is hydrocarbyl or substituted hydrocarbyl;
each R^{118} is independently hydrogen, hydrocarbyl or substituted hydrocarbyl;

10 G and L are both N or G is CR^{57} and L is CR^{55} ;
 R^{55} , R^{56} and R^{57} are each independently hydrogen, hydrocarbyl or substituted hydrocarbyl, or any two of R^{55} , R^{56} and R^{57} taken together form a ring;

R^{78} is hydrocarbyl or substituted hydrocarbyl;
15 R^{79} , R^{80} , R^{81} , R^{82} , R^{83} , R^{84} , R^{85} , R^{86} , R^{87} , R^{88} and R^{89} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or a functional group;

R^{90} , R^{91} , R^{92} and R^{93} are each independently hydrocarbyl or substituted hydrocarbyl;

20 R^{94} and R^{95} are each independently hydrocarbyl or substituted hydrocarbyl;

R^{96} , R^{97} , R^{98} , and R^{99} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group;

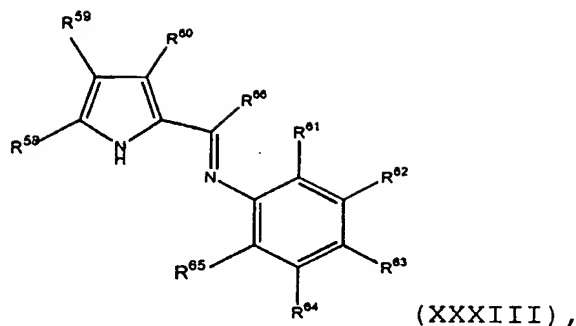
25 both of T are S (sulfur) or NH (amino);
each E is N (nitrogen) or CR^{108} wherein R^{108} is hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group;

R^{100} , R^{101} , R^{102} , R^{103} , R^{104} , R^{105} , R^{106} , and R^{107} are
30 each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or a functional group;

R^{109} , R^{110} , R^{111} , R^{112} , R^{113} , R^{114} , R^{115} and R^{116} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group; and

35 R^{28} and R^{29} are each independently hydrogen, hydrocarbyl or substituted hydrocarbyl.

Also disclosed herein is a compound of the formula



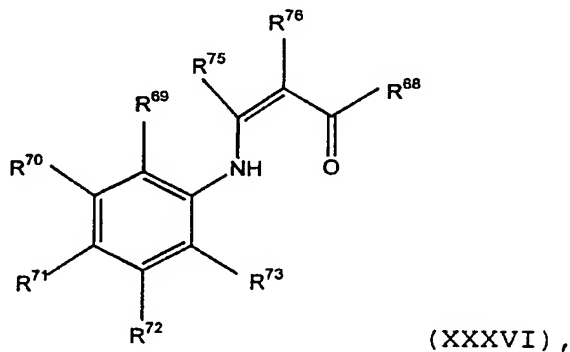
wherein:

R^{58} , R^{59} , R^{60} , R^{62} , R^{63} and R^{64} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or a functional group, and provided that any two of these groups vicinal to one another taken together may form a ring, or if vicinal to R^{61} or R^{65} form a ring with them;

R^{66} is hydrogen, hydrocarbyl or substituted hydrocarbyl; and

R^{61} and R^{65} are each independently hydrocarbyl containing 2 or more carbon atoms, or substituted hydrocarbyl containing 2 or more carbon atoms, and provided that R^{61} and R^{65} may form a ring with any group vicinal to it.

This invention also concerns a compound of the formula



wherein:

R^{68} is hydrocarbyl, substituted hydrocarbyl, $-SR^{117}$, $-OR^{117}$, or $-NR^{118}_2$, R^{76} is hydrogen, a functional group, hydrocarbyl or substituted hydrocarbyl, and R^{75} is hydrocarbyl or substituted hydrocarbyl, and provided

that R⁶⁸ and R⁷⁶ or R⁷⁵ and R⁷⁶ taken together may form a ring;

R¹¹⁷ is hydrocarbyl or substituted hydrocarbyl;
each R¹¹⁸ is independently hydrogen, hydrocarbyl

5 or substituted hydrocarbyl;

R⁷⁰, R⁷¹ and R⁷² are each independently
hydrogen, hydrocarbyl, substituted hydrocarbyl or a
functional group;

R⁶⁹ and R⁷³ are hydrocarbyl containing 3 or
10 more carbon atoms, substituted hydrocarbyl containing 3
or more carbon atoms or a functional group;

and provided that any two of R⁷⁰, R⁷¹, R⁷², R⁶⁹
and R⁷³ vicinal to one another together may form a
ring.

15

DETAILS OF THE INVENTION

Herein, certain terms are used. Some of them are:

- A "hydrocarbyl group" is a univalent group
containing only carbon and hydrogen. If not otherwise
stated, it is preferred that hydrocarbyl groups herein
20 preferably contain 1 to about 30 carbon atoms.

- By "substituted hydrocarbyl" herein is meant
a hydrocarbyl group which contains one or more
substituent groups which are inert under the process
conditions to which the compound containing these
25 groups is subjected. The substituent groups also do
not substantially interfere with the process. If not
otherwise stated, it is preferred that substituted
hydrocarbyl groups herein contain preferably 1 to about
30 carbon atoms. Included in the meaning of
30 "substituted" are heteroaromatic rings.

- By "(inert) functional group" herein is
meant a group other than hydrocarbyl or substituted
hydrocarbyl which is inert under the process conditions
to which the compound containing the group is
35 subjected. The functional groups also do not
substantially interfere with any process described
herein that the compound in which they are present may
take part in. Examples of functional groups include

halo (fluoro, chloro, bromo and iodo), ether such as -OR²⁵, -CO₂R²⁵, -NO₂, and -NR²⁵₂, wherein R²⁵ is hydrocarbyl or substituted hydrocarbyl. In cases in which the functional group may be near a nickel atom the functional group should not coordinate to the metal atom more strongly than the groups in compounds which are shown as coordinating to the metal atom, that is they should not displace the desired coordinating group.

10 • By a "polymerization process" herein (and the polymers made therein) is meant a process which produces a polymer with a degree of polymerization (DP) of about 5 or more, preferably about 10 or more, more preferably about 40 or more [except where otherwise noted, as in P in compound (XVII)]. By "DP" is meant 15 the average number of repeat (monomer) units in the polymer.

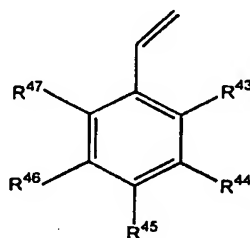
 • By "aryl" herein is meant a monovalent radical whose free valence is to a carbon atom of an aromatic ring. Unless otherwise noted herein, 20 preferred aryl groups contain carbocyclic rings, but heterocyclic rings are also included within the definition of "aryl". The aryl radical may contain one ring or may contain 2 or more fused rings, such as 9-anthracenyl or 1-naphthyl. Unless otherwise stated 25 aryl groups preferably contain 5 to 30 carbon atoms.

 • By "substituted aryl" herein is meant an aryl radical substituted with one or more groups that do not interfere with the synthesis of the compound or 30 the resulting polymerization. Suitable substituents include alkyl, aryl such as phenyl, halo, alkoxy, ester, dialkylamino and nitro. Unless otherwise stated, substituted aryl groups contain 5 to about 30 carbon atoms.

35 • By a "monoanionic ligand" is meant a ligand with one negative charge.

 • By a "neutral ligand" is meant a ligand that is not charged.

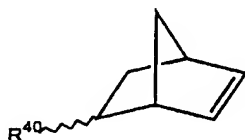
- "Alkyl group" and "substituted alkyl group" have their usual meaning (see above for substituted under substituted hydrocarbyl). Unless otherwise stated, alkyl groups and substituted alkyl groups preferably have 1 to about 30 carbon atoms.
- By a styrene herein is meant a compound of the formula



(XXXIV)

- 10 wherein R^{43} , R^{44} , R^{45} , R^{46} and R^{47} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group, all of which are inert in the polymerization process. It is preferred that all of R^{43} , R^{44} , R^{45} , R^{46} and R^{47} are hydrogen.
- 15 Styrene (itself) is a preferred styrene.

- By a norbornene is meant ethylidene norbornene, dicyclopentadiene, or a compound of the formula



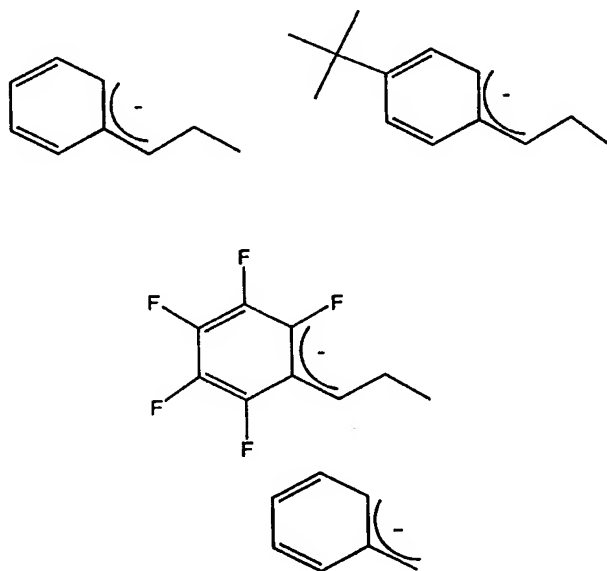
(XXXV);

- 20 wherein R^{40} is hydrogen or hydrocarbyl containing 1 to 20 carbon atoms. It is preferred that R^{40} is hydrogen or alkyl, more preferably hydrogen or n-alkyl, and especially preferably hydrogen. The norbornene may be
- 25 substituted by one or more hydrocarbyl, substituted hydrocarbyl or functional groups in the R^{40} or other positions, with the exception of the vinylic hydrogens, which remain. Norbornene (itself), dimethyl endo-norbornene-2,3-dicarboxylate, t-butyl 5-norbornene-2-carboxylate are preferred norbornenes and norbornene
- 30 (itself) is especially preferred.

- By a π -allyl group is meant a monoanionic ligand with 3 adjacent sp^2 carbon atoms bound to a metal center in an η^3 fashion. The three sp^2 carbon atoms may be substituted with other hydrocarbyl groups or functional groups. Typical π -allyl groups include



- wherein R is hydrocarbyl. By a π -benzyl group is meant a π -allyl ligand in which two of the sp^2 carbon atoms are part of an aromatic ring. Typical π -benzyl groups include



and

- π -Benzyl compounds usually initiate polymerization of the olefins fairly readily even at room temperature, but π -allyl compounds may not necessarily do so. Initiation of π -allyl compounds can be improved by using one or more of the following methods:
- Using a higher temperature such as about 80°C.

- Decreasing the bulk of the monoanionic ligand, such as aryl being 2,6-dimethylphenyl instead of 2,6-diisopropylphenyl.

- Making the π -allyl ligand more bulky, such
5 as using



rather than the simple π -allyl group itself.

- Having a Lewis acid or a material that acts
10 as a Lewis acid present while using a π -allyl or π -benzyl group, especially a functional π -allyl or π -benzyl group. Relatively weak Lewis acids such as triphenylborane, tris(pentafluorophenyl)borane, tris(3,5-trifluoromethylphenyl)borane, and
15 poly(methylaluminoxane) are preferred. Suitable functional groups include chloro and ester.

Lewis acids may also be optionally present when compounds containing L^1 and/or L^2 are present in the polymerization, even when L^2 is not a π -allyl or π -
20 benzyl group. It is believed that the Lewis acid, if present, may help to remove L^1 (if present) from the nickel atom, thereby facilitating the coordination of the olefin to the Ni atom. If a compound containing L^1 and/or L^2 does not act as a polymerization catalyst, it
25 is suggested that a Lewis acid, such as those mentioned above be added to the process to determine if polymerization will then take place. Such testing requires minimal experimentation, and is illustrated in the Examples. Not surprisingly, with any particular
30 set of polymerization process ingredients, some Lewis acids may be more effective than others.

In preferred olefins herein, R^{67} is hydrogen or n-alkyl containing 1 to 20 carbon atoms (an α -olefin), more preferably n-alkyl containing 1 to 8 carbon atoms,
35 or more preferably hydrogen (e.g., ethylene) or methyl (e.g., propylene), and especially preferably hydrogen. A combination of ethylene and $H_2C=CHR^{67}$ wherein R^{67} n-alkyl containing 1 to 8 carbon atoms is also

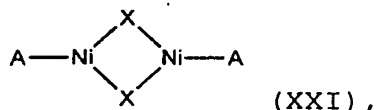
preferred, and a combination of ethylene and propylene is more preferred. It is also preferred that s is 2 or more, and/or R^{77} is alkyl, especially preferably methyl or ethyl. When $H_2C=CH(CH_2)_sCO_2R^{77}$ is present as one of the olefins, it is preferred that R^{67} is hydrogen.

While not all homopolymers and copolymers of the olefinic monomers useful herein can be made using the polymerization processes described herein, most homopolymers and many copolymers can be made. The following homopolymers can be readily made in these polymerization processes: polyethylene, polystyrene, a polynorbornene, poly- α -olefins (often lower molecular weight polymers obtained), polycyclopentene (often lower molecular weight polymers obtained). Attempted homopolymerization of functionalized norbornenes often does not proceed, nor do homopolymerizations of compounds of the formula $H_2C=CH(CH_2)_sCO_2R^{77}$. Many copolymers can be made, including ethylene/ α -olefins, styrene/norbornene copolymers, copolymers of 2 or more norbornenes including functionalized norbornenes, copolymers of ethylene and cyclopentene, copolymers of ethylene and a norbornene, and copolymers of ethylene and $H_2C=CH(CH_2)_sCO_2R^{77}$.

Not every variation of every nickel complex listed in the various polymerizations will make every one of the polymers listed immediately above. However, many of them will make most if not all of these types of polymers. While no hard and fast rules can be given, it is believed that for polymerizations which include ethylene and/or α -olefins, steric hindrance about the nickel atom caused by substituent groups is desirable for making polymers, especially higher molecular weight polymers, while for polymers containing one or more of a styrene and/or a norbornene such steric hindrance is not as important.

The $Ni[II]$ complexes that are useful herein for the polymerization of ethylene contain a bidentate monoanionic ligand (other than a combined L^1 and L^2) in

which the coordinating atoms are 2 nitrogen atoms, a nitrogen atom and an oxygen atom, a phosphorous atom and a sulfur atom, or an oxygen atom and a sulfur atom. Compounds of formulas (I) through (VI), (XVIII), (XXVII), and (XXXVII)-(XXXX) can be made by reaction of 2 moles of the anionic form of the ligand with one mole of the appropriate nickel allyl or benzyl precursor (XXI),



wherein X is preferably chlorine or bromine and A is a π -allyl or π -benzyl group, to form the nickel compound (see Examples 17-40 and 469-498).

Compounds of formulas (VII) through (XII), (XIX), (XXVIII), and (XXXI)-(XXXIV) can be synthesized by protonation of a suitable Ni[0] or Ni[II] precursor by the neutral ligand or by reaction of a suitable Ni[II] precursor with the anionic form of the ligand.

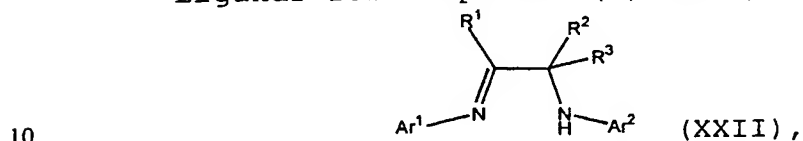
Examples of suitable Ni[0] and Ni[II] precursors include Ni(1,4-cyclooctadiene)₂,

(N,N,N',N'-tetramethylethylenediamine)NiMe₂, 2,2'-bipyridineNiMe₂, (MePPh₂)₃NiMe₂, [Ni(OMe)Me(PPh₃)]₂, [Ni(OMe)Me(PMe₃)]₂, NiBr₂, N,N,N',N'-tetramethylethylenediamine)Ni(acetylacetonate)₂, (1,2-dimethoxyethane)NiBr₂, N,N,N',N'-tetramethylethylenediamine)Ni(CH₂=CHCO₂CH₃)₂, (pyridine)₂Ni(CH₂=CHCO₂CH₃)₂, and (acetylacetonate)Ni(Et)(PPh₃). The addition of phosphine or ligand "sponges" such as CuCl, BPh₃ or tris(pentafluorophenyl)borane may aid such reactions.

Some of the nickel compounds herein such as (XXXIX), (XXXX), (XXXIII) and (XXXIV) may exist as "dimers" or monomers, or in equilibrium between the two. The dimer contains two nickel atoms, each nickel atom being coordinated to L¹ and L², wherein L¹ and L² combined may be a bidentate monoanionic ligand such as a π -allyl or π -benzyl group, and both Ni atoms "share" coordination to each of the other ligands present. As

described herein, depiction of the monomeric compound also includes the dimeric compound, and vice versa. Whether any particular nickel compound is (predominantly) a monomer or dimer, or both states are detectable will depend on the ligands present. For instance it is believed that as the ligands become more bulky, especially about the nickel atom, the tendency is to form a monomeric compound.

Ligands for compounds (I) and (VII) of the formula

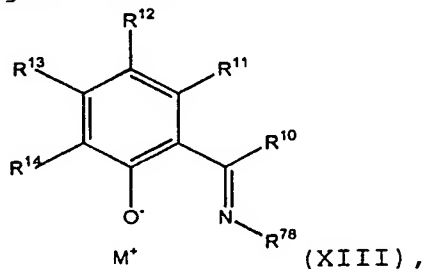


can be made by reaction of an alpha-diimine of the formula $\text{Ar}^1\text{N}=\text{CR}^1-\text{CR}^2=\text{NAr}^2$ with one equivalent of a compound of the formula R^3Li , see for instance M. G. Gardner, et al., Inorg. Chem., vol. 34 p. 4206-4212 (1995). In another case, a ligand of the formula



can be made by the condensation of 1,2-cyclohexadione with the corresponding aromatic amine(s), see for instance R. van Asselt, et. al, Recl. Trav. Chim. Pays-Bas, vol. 113, p. 88-98 (1994). Note that in (XXIII) R^1 , R^2 and R^3 taken together form a ring, with R^2 and R^3 both "part of" a double bond to the same carbon atom. These ligands can then be converted to their corresponding nickel complexes by the methods described above.

Compounds of the formula (II) can be made by the reaction of a ligand of the formula

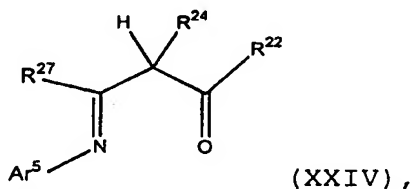


while compounds of the formula (VIII) can be made from the protonated form of (XIII). (XIII) can be made from the corresponding salicylaldehyde (when R¹⁰ is hydrogen) and aromatic amine, followed by reaction with an alkali metal base (such as an alkali metal hydride) to form the aryloxide.

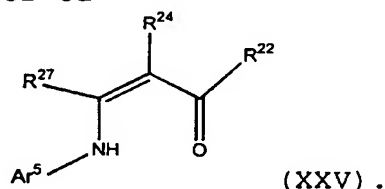
(III) and (IX) can be made by reacting pyrrole-2-carboxyaldehyde with the appropriate aromatic amine to form the pyrrole-2-imine, followed by reaction with a strong base to form the pyrrole anion, and then reaction with the nickel precursors described above to form the nickel[II] complex.

Similarly, (IV) and (X) can be formed from an alkali metal thiophene-2-carboxylate and the nickel precursors described above.

When K is CR²⁷ the ligand for (V) and (XI) can be made by the reaction of the corresponding ketone (which may contain other functional groups) with an aromatic amine to give



which is a tautomer of

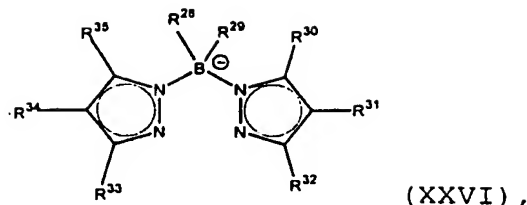


Useful ketones for making (V) and (XI) include ethyl acetoacetate, ethyl 2-ethylacetoacetate, isobutyl acetoacetate, t-butyl acetoacetate, S-t-butyl acetoacetate, allyl acetoacetate, ethyl 2-methylacetoacetate, methyl 2-chloroacetoacetate, ethyl 2-chloroacetoacetate, methyl 4-chloroacetoacetate, ethyl 4-chloroacetoacetate, ethyl 4,4,4-trifluoroacetoacetate, S-methyl 4,4,4-trifluoro-3-oxothiobutyrate, 2-methoxyethyl

acetoacetate, methyl 4-methoxyacetoacetate, methyl
propionylacetate, ethyl propionyl acetate, ethyl
isobutyrylacetate, methyl 4,4-dimethyl-3-oxopentanoate,
ethyl butyrylacetate, ethyl 2,4-dioxovalerate, methyl
5 3-oxo-6-octenoate, dimethyl 1,3-acetonedicarboxylate,
diethyl 1,3-acetonedicarboxylate, di-t-butyl
1,3-acetonedicarboxylate, dimethyl 3-oxoadipate,
diethyl 3-oxopimelate, dimethyl acetylsuccinate,
diethyl acetylsuccinate, diethyl 2-acetylglutarate,
10 methyl 2-cyclopentatecarboxylate, ethyl
2-cyclopentanecarboxylate, ethyl
4-methyl-2-cyclohexanone-1-carboxylate, ethyl
4-methyl-2-cyclohexanone-1-carboxylate, ethyl
3-(1-adamantyl)-3-oxopropionate, methyl
15 2-oxo-1-cycloheptanecarboxylate, N-t-butylacetoamide,
2-chloro-N,N-dimethylacetoacetamide,
4,4,4-trifluoro-1-phenyl-1,3-butanedione,
4,4,4-trifluoro-1-(2-naphthyl)-1,3-butanedione,
2-acetyl-1-tetralone, ethyl 2-benzylacetoacetate,
20 methyl 1-benzyl-4-oxo-3-piperidinecarboxylate
hydrochloride, benzyl acetoacetate, acetoacetanilide,
o-acetoacetotoluide,
N-(2,4-dimethylphenyl)-3-oxobutyramide,
o-acetoacetanisidide, 4'-chloroacetoacetanilide, and
25 1,1,1-trifluoro-3-thianoylacetone.

When K is N in (V) and (XI), and R^{24} is nitrile,
the ligand can be made by the reaction of $R^{22}C(O)CH_2CN$ with
the diazonium salt of the corresponding arylamine, see
for instance V.P. Kurbatov, et al., Russian Journal of
30 Inorganic Chemistry, vol. 42, p. 898-902 (1997). This
paper also reviews methods of making ligands wherein K
is CR^{27} .

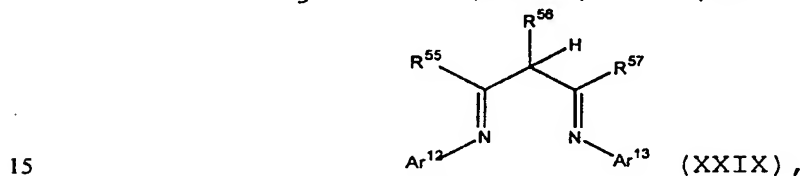
The boron containing ligands needed for compounds
(VI) and (XII),



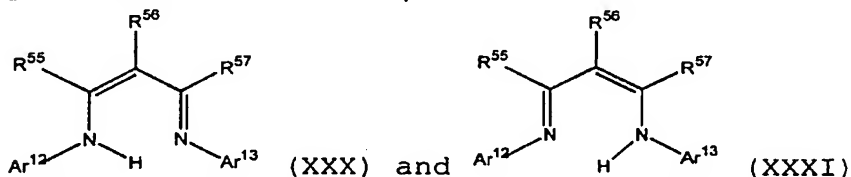
can be made by known procedures, see for instance
S. Trofimenko, Prog. Inorg. Chem., vol. 34, p. 115-210
(1986) and S. Trofimenko, Chem. Rev., vol. 93, p. 943-
5 980 (1993).

The synthesis of the tropolone-type ligands
required for (XVIII) and (XIX) are described in
J. J. Drysdale, et al., J. Am. Chem. Soc., vol. 80, p.
3672-3675 (1958); W. R. Brasen, et al., vol. 83, p.
10 3125-3138 (1961); and G. M. Villacorta, et al., J. Am.
Chem. Soc., vol. 110, p. 3175-3182 (1988). These can
be reacted as described above to form the corresponding
nickel complex.

The ligand for (XXVII) and (XXVIII),

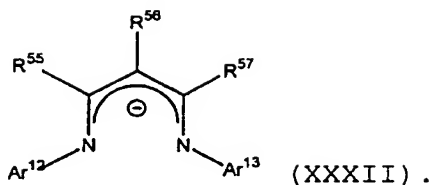


or either of its tautomers,



can be made by reaction of the appropriate α,χ -dioxo
compound such as a 1,3-dione or 1,3-dial or similar
20 compound with the appropriate aromatic amine, see for
instance J. E. Parks, et al., Inorg. Chem., vol. 7, p.
1408 (1968); R. H. Holm, Prog. Inorg. Chem., vol. 14,
p. 241 (1971); and P. C. Healy, et al., Aust. J. Chem.,
vol. 32, p. 727 (1979).

25 If the ligand precursor may form a tautomer, the
ligand itself may usually be considered a tautomer.
For instance, the monoanionic ligand derived from
(XXIX) and its tautomers may be written as



In (XXVII) and (XXVIII) when L and/or G is N, the ligand can be made by the method described in Y.A. Ibrahim, et al., Tetrahedron, vol. 50, p.

11489-11498(1994) and references described therein.

The ligands for (XXXVII) and (XXXI) can be made by methods described in Phosphorous, Sulfur and Silicon, vol. 47, p. 401 et seq. (1990), and analogous reactions.

The ligands for (XXXVIII) and (XXXXII) can be made by reacting R_2PLi (from R_2PH and $n-BuLi$) with propylene sulfide to form $R_2CH_2CH(CH_3)SLi$, and analogous reactions.

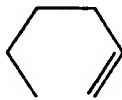
The ligands for (XXXIX) and (XXXXIII), and for (XXXX) and (XXXXIV) are commercially available. Those used herein were bought from Aldrich Chemical Co., Inc., Milwaukee, WI, U.S.A.

In the compounds (and ligands in those compounds) (I) through (XII), (XVIII), (XIX), (XXVII), (XXVIII), and (XXXVII)-(XXXXIV), certain groups are preferred. When present, they are:

R^1 and R^2 are both hydrogen; and/or

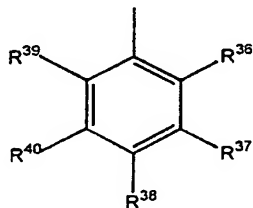
R^3 is alkyl or aryl containing 1 to 20 carbon atoms, more preferably R^3 is t-butyl; and/or

R^1 , R^2 and R^3 taken together are



; and/or

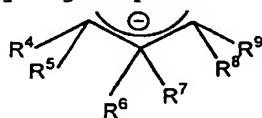
Ar^1 , Ar^2 , Ar^3 , Ar^4 , Ar^5 , Ar^{10} and Ar^{11} are each independently



(XIV)

wherein R^{36} , R^{37} , R^{38} , R^{39} and R^{40} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group, provided that any 2 of R^{36} , R^{37} , R^{38} , R^{39} and R^{40} that are vicinal to one another taken together may form a ring (for example the group 9-anthracenyl), and it is especially preferred that R^{36} and R^{39} are halo, phenyl or alkyl containing 1 to 6 carbon atoms, and it is more preferred that R^{36} and R^3 are methyl, bromo, chloro, t-butyl, hydrogen, or isopropyl; and/or

R^{78} is Ar^3 , which is aryl or substituted aryl; Ar^1 , Ar^2 , Ar^3 , Ar^4 , Ar^5 , Ar^{10} and Ar^{11} are each independently 2-pyridyl or substituted 2-pyridyl; if a π -allyl group is



(XX)

then R^4 , R^5 , R^6 , and R^8 are hydrogen; and/or R^4 , R^5 , R^6 , R^7 , R^8 and R^9 are hydrogen; and/or R^4 , R^5 , R^6 , and R^7 are hydrogen and R^8 and R^9 are methyl; one of R^7 or R^9 is $-CO_2R^{41}$ or chloro, and the other is hydrogen, and wherein R^{41} is hydrocarbyl, preferably alkyl containing 1 to 6 carbon atoms; and/or R^{11} , R^{12} , R^{13} and R^{14} are each independently chloro, bromo, iodo, alkyl, alkoxy, hydrogen or nitro; and/or

R^{11} and R^{12} taken together form an aromatic carbocyclic 6-membered ring; and/or

R^{14} and R^{12} are both chloro, bromo, iodo, t-butyl or nitro; and/or

R^{11} and R^{13} are methoxy; R^{14} is hydrogen and R^{12} is nitro; and/or one or more of R^{11} , R^{12} , R^{13} and R^{14} are hydrogen; and/or

R^{16} , R^{17} , R^{18} , R^{19} , R^{20} , and R^{21} are hydrogen; and/or

R^{16} , R^{17} , R^{18} , R^{19} , and R^{20} are hydrogen and
 R^{21} is methyl; and/or

K is CR^{27} ; and/or

R^{27} is hydrogen, hydrocarbyl, substituted
5 hydrocarbyl, or a functional group; and/or

R^{27} is alkyl, more preferably methyl; and/or

R^{24} is hydrogen, alkyl, cyano, or halo, more
preferably hydrogen; and/or

10 R^{22} is hydrocarbyl or $-OR^{117}$, wherein R^{117} is
hydrocarbyl, more preferably alkyl containing 1 to 6
carbon atoms, or R^{22} is phenyl; and/or

R^{32} and R^{33} are both alkyl containing 1 to 6
carbon atoms or phenyl, more preferably isopropyl;
15 and/or

R^{28} and R^{29} are both hydrogen or phenyl; and/or

R^{30} , R^{31} , R^{34} and R^{35} are all hydrogen; and/or

R^{31} and R^{32} taken together and R^{33} and R^{34}

taken together are both a 6-membered aromatic
20 carbocyclic ring having a t-butyl group vicinal to the
 R^{32} and R^{33} positions; and/or

R^{50} , R^{51} , R^{52} , R^{53} and R^{54} are hydrogen; and/or

L is CR^{55} wherein R^{55} is hydrocarbyl, hydrogen,
or substituted hydrocarbyl; and/or

25 G is CR^{57} wherein R^{57} is hydrocarbyl, hydrogen
or substituted hydrocarbyl; and/or

more preferably R^{55} and R^{57} are both alkyl or
fluorinated alkyl, more preferably methyl; and/or

R^{56} is hydrogen; and/or

30 Ar^{12} and Ar^{13} are both 2,6-diisopropylphenyl;
and/or

R^{79} , R^{80} , R^{81} , R^{82} , R^{83} , R^{84} , R^{85} , R^{86} , R^{87} , R^{88} and
 R^{89} are each independently hydrogen or alkyl; and/or

R^{90} , R^{91} , R^{92} and R^{93} are each independently
35 hydrocarbyl, more preferably aryl, and especially
preferably phenyl; and/or

R^{94} and R^{95} are each independently hydrocarbyl;
and/or

R^{96} , R^{97} , R^{98} , and R^{99} are each independently hydrogen or hydrocarbyl; and/or

E is N or CR^{108} ; and/or

R^{108} is hydrogen or hydrocarbyl; and/or

5 R^{100} , R^{101} , R^{102} , R^{103} , R^{104} , R^{105} , R^{106} , and R^{107} is each independently hydrogen, hydrocarbyl, or halo; and/or

R^{109} , R^{110} , R^{111} , R^{112} , R^{113} , R^{114} , R^{115} and R^{116} are each independently hydrogen or hydrocarbyl.

10 Specific preferred compounds (I)-(IV) and (VI) are given in Table A. The same groupings shown in the Table are preferred for the analogous compounds (VII)-(X) and (XII). In all of these compounds, where applicable, R^4 , R^5 , R^6 , R^8 , R^9 [in (XX) above], R^{15} ,
15 R^{16} , R^{17} , R^{18} , R^{19} , R^{20} , R^{30} , and R^{35} are all hydrogen (with the exceptions in the footnotes), R^{10} is hydrogen or methyl, R^{21} is hydrogen or methyl, and R^7 is $-CO_2CH_3$ (with the exceptions in the footnotes). In compounds wherein L_1 and L_2 appear, and especially in compounds
20 of formula (VIII) it is preferred that L_1 is a nitrile, such as benzonitrile, p-methylbenzonitrile methyl nitrile, or pyridine or a substituted pyridine such as 2,6-dimethyl pyridine. A preferred L_2 is an alkyl group, especially methyl. L_1 and L_2 taken together may
25 be a π -allyl or π -benzyl group, but for all compounds in which L_1 and L_2 are present (i.e. combined) it is preferred that they are not a π -allyl or π -benzyl group.

Table B give specific preferred compounds for (V),
30 (XXXVII) and (XXXIX) as well as the corresponding compounds (XI), (XXXI) and (XXXIII) respectively. In all of these compounds Ar^5 is 2,6-diisopropylphenyl, K is CCH_3 , R^{24} , R^{79} , R^{80} , R^{82} , R^{85} , R^{87} , R^{88} , and R^{89} are hydrogen, R^{90} , R^{91} , R^{92} , and R^{93} are phenyl.

35 In a specific preferred compounds (XXVII) and the corresponding (XXVIII), Ar^{12} and Ar^{13} are 2,6-diisopropylphenyl, L and G are CCH_3 , and R^{56} is hydrogen.

In a specific preferred compound (XXXVIII) and the corresponding (XXXXVII), R^{94} and R^{95} are each cyclohexyl, R^{96} , R^{97} and R^{98} are hydrogen, and R^{99} is methyl.

- 5 In a specific preferred compound (XXXX) and the corresponding (XXXXIV), R^{110} , R^{111} , R^{114} and R^{115} are hydrogen and R^{109} , R^{112} , R^{113} and R^{116} are methyl.

Table A

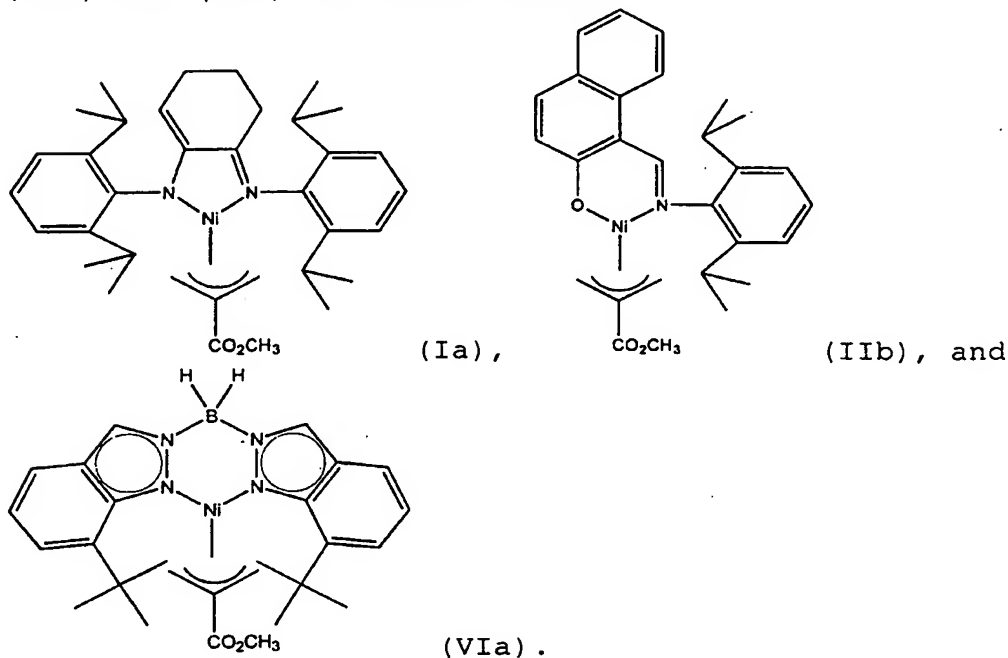
Comp ^d	R ¹	R ²	R ³	Ar ¹ and Ar ²	Ar ³	R ¹¹	R ¹²	R ¹³	R ¹⁴	Ar ⁴	R ²⁸	R ²⁹	R ³⁰	R ³¹	R ³²	R ³³	R ³⁴	R ³⁵
Ia	a	a	a	2,6-IPr-Ph	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ib	H	H	t-butyl	2,6-IPr-Ph	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ila	-	-	-	-	2,6-IPr-Ph	H	t-butyl	H	t-butyl	-	-	-	-	-	-	-	-	-
Ilb	-	-	-	-	2,6-IPr-Ph	b	b	H	H	-	-	-	-	-	-	-	-	-
Ilc	-	-	-	-	2,6-Me-Ph	b	b	H	H	-	-	-	-	-	-	-	-	-
Ild	-	-	-	-	2,6-Me-Ph	H	Cl	H	Cl	-	-	-	-	-	-	-	-	-
Ile	-	-	-	-	2,6-IPr-Ph	H	Cl	H	Cl	-	-	-	-	-	-	-	-	-
Ilf	-	-	-	-	2,6-IPr-Ph	H	NO ₂	H	NO ₂	-	-	-	-	-	-	-	-	-
Ilg	-	-	-	-	2,4,6-t-butyl-Ph	H	NO ₂	H	NO ₂	-	-	-	-	-	-	-	-	-
Ilh	-	-	-	-	2,6-Br-4-Me-Ph	H	NO ₂	H	NO ₂	-	-	-	-	-	-	-	-	-
Ili	-	-	-	-	2,6-Me-Ph	H	NO ₂	H	NO ₂	-	-	-	-	-	-	-	-	-
Ilj	-	-	-	-	2,6-IPr-Ph	H	NO ₂	H	H	-	-	-	-	-	-	-	-	-
Ilk	-	-	-	-	2-t-Bu-Ph	H	NO ₂	H	NO ₂	-	-	-	-	-	-	-	-	-
Ill	-	-	-	-	2,6-Me-Ph	H	t-butyl	H	t-butyl	-	-	-	-	-	-	-	-	-
IIm	-	-	-	-	2,6-Br-4-F-Ph	H	t-butyl	H	t-butyl	-	-	-	-	-	-	-	-	-
IIn	-	-	-	-	2-Cl-6-Me-Ph	H	NO ₂	H	NO ₂	-	-	-	-	-	-	-	-	-
Ilo	-	-	-	-	f	H	NO ₂	H	NO ₂	-	-	-	-	-	-	-	-	-
Ilp	-	-	-	-	2,6-IPr-Ph	H	f	H	f	-	-	-	-	-	-	-	-	-
Iliq	-	-	-	-	2,6-IPr-Ph	OMe	H	OMe	H	-	-	-	-	-	-	-	-	-
Ilr	-	-	-	-	2,6-Br-4-F-Ph	b	b	H	H	-	-	-	-	-	-	-	-	-

f 1,2,3,4-tetrahydro-1-naphthyl

Table B

Cmpd	R ²²	R ⁸¹	R ⁸³	R ⁸⁴	R ⁸⁶	T	E	R ¹⁰⁰	R ¹⁰¹	R ¹⁰²	R ¹⁰³	R ¹⁰⁴	R ¹⁰⁵	R ¹⁰⁶	R ¹⁰⁷
Va	OMe	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vb	Me	-	-	-	-	-	-	-	-	-	-	-	-	-	-
XXXVIIa	-	Me	H	H	Me	-	-	-	-	-	-	-	-	-	-
XXXVIIb	-	H	Me	Me	H	-	-	-	-	-	-	-	-	-	-
XXXIXa	-	-	-	-	-	S	N	Cl	Cl	Cl	Cl	Cl	Cl	Cl	Cl
XXXIXb	-	-	-	-	-	NH	CCH ₃	Br	H	H	Br	Br	H	H	Br

For clarity, the structures of compounds (Ia), (IIb) and (VIa) are shown below;



5

In (XXXIII) it is preferred that:

R^{58} , R^{59} , R^{60} , R^{62} , R^{63} and R^{64} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or a functional group, and provided that any two of these groups vicinal to one another taken together may form a ring;

R^{66} is hydrogen, hydrocarbyl or substituted hydrocarbyl; and

R^{61} and R^{65} are each independently hydrocarbyl containing 2 or more carbon atoms, or substituted hydrocarbyl containing 2 or more carbon atoms.

R^{58} , R^{59} , R^{60} , R^{62} , R^{63} and R^{64} are each hydrogen; and/or

R^{66} is hydrogen; and/or

R^{61} and R^{65} are each independently alkyl, and more preferred that both are isopropyl or methyl.

In a preferred compound or ligand (XVIII) and (XIX):

R^{50} , R^{51} , R^{52} , R^{53} and R^{54} are hydrogen; and/or

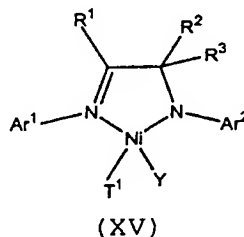
Ar^{10} and Ar^{11} are 2,6-dialkyl substituted phenyl, more preferably 2,6-dimethylphenyl or 2,6-diisopropylphenyl.

Monoanionic ligands which the olefins herein may add to include hydride, alkyl, substituted alkyl, aryl, substituted aryl, or $\text{R}^{26}\text{C}(=\text{O})-$ wherein R^{26} is hydrocarbyl or substituted hydrocarbyl, and groups π -allyl and π -benzyl groups such as $\eta^3\text{-C}_8\text{H}_{13}$, see for instance J. P. Collman, et al., Principles and Applications of Organotransition Metal Chemistry, University Science Book, Mill Valley, CA, 1987. Such groups are also described in World Patent Application WO 96/23010.

In compound (XXXVI) it is preferred that R^{68} is $-\text{OR}^{117}$ or aryl, and/or R^{75} is hydrocarbyl or substituted hydrocarbyl, and/or R^{76} is hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group, more preferably hydrogen, hydrocarbyl or substituted hydrocarbyl.

In the second polymerization process described herein a nickel[II] complex such as any one of (VII)-(XII), (XIX), (XXVIII) or (XXXXI)-(XXXXIV) is either added to the polymerization process or formed in situ in the process. In fact, more than one such complex may be formed during the course of the process, for instance formation of an initial complex and then reaction of that complex to form a living ended polymer containing such a complex.

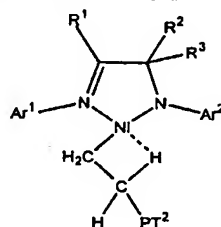
An example of such a complex which may be formed initially in situ is



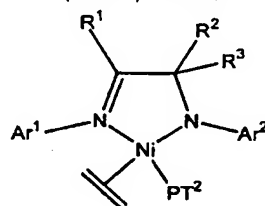
wherein R^1 through R^3 , Ar^1 and Ar^2 are as defined above, T^1 is hydride, alkyl, or $\text{R}^{42}\text{C}(=\text{O})-$ wherein R^{42} is hydrocarbyl or substituted hydrocarbyl or any other

monoanionic ligand which ethylene may add to, and Y is a neutral ligand, or T^1 and Y taken together are a bidentate monoanionic ligand which ethylene may add to. Similar complexes may also be formed with the ligands in (VIII)-(XII), (XIX), (XXVIII) and (XXXI)-(XXXIV). Such complexes may be added directly to the process or formed in situ.

After the olefin polymerization has started, the complex may be in forms such as



(XVI) and



(XVII)

wherein R^1 through R^3 , Ar^1 and Ar^2 are as defined above, P is a divalent (poly)olefin group [the specific olefin shown in (XVI) and (XVII) is ethylene], $-(CH_2)_x-$ wherein x is an integer of 2 or more, and T^2 is an end group, for example the groups listed for T^1 above. (XVI) is a so-called agostic form complex. Similar complexes may also be formed with the ligands in (VIII)-(XII), (XI), (XXVIII) and (XXXI)-(XXXIV). Analogous compounds with other olefins in place of ethylene also may be formed. In all the polymerization processes herein, the temperature at which the olefin polymerization is carried out is about -100°C to about $+200^\circ\text{C}$, preferably about 0°C to about 150°C , more preferably about 25°C to about 100°C . The olefin concentration at which the polymerization is carried out is not critical, atmospheric pressure to about 275 MPa being a suitable range for ethylene and propylene.

The polymerization processes herein may be run in the presence of various liquids, particularly aprotic organic liquids. The catalyst system, olefin, and polyolefin may be soluble or insoluble in these liquids, but obviously these liquids should not prevent the polymerization from occurring. Suitable liquids include alkanes, cycloalkanes, selected halogenated hydrocarbons, and aromatic hydrocarbons. Hydrocarbons are the preferred solvent. Specific useful solvents include hexane, toluene, benzene, chloroform, methylene chloride, 1,2,4-trichlorobenzene, p-xylene, and cyclohexane.

The catalysts herein may be "heterogenized" by coating or otherwise attaching them to solid supports, such as silica or alumina. Where an active catalyst species is formed by reaction with a compound such as an alkylaluminum compound, a support on which the alkylaluminum compound is first coated or otherwise attached is contacted with the nickel compound precursor to form a catalyst system in which the active nickel catalyst is "attached" to the solid support. These supported catalysts may be used in polymerizations in organic liquids, as described in the immediately preceding paragraph. They may also be used in so-called gas phase polymerizations in which the olefin(s) being polymerized are added to the polymerization as gases and no liquid supporting phase is present.

Included herein within the definitions of all the polymerization processes are mixtures of starting materials that lead to the formation in situ of the nickel compounds specified in all of the polymerization processes.

In the Examples all pressures are gauge pressures. Quantitative ^{13}C NMR data for the polymers was obtained using a 10 mm probe on typically 15-20% solutions of the polymer and 0.05M Cr(acetylacetonate)₃ in 1,2,4-trichlorobenzene are 120-140°C. For a full

description of determination of branching by ^{13}C and ^1H NMR, and for a definition of branches, see World Patent Application 96/23010, which is hereby included by reference.

5 In the Examples, the following abbreviations are used:

Am - amyl
Bu - butyl
Cy - cyclohexyl
10 E - ethylene
Et - ethyl
GPC - gel permeation chromatography
Me - methyl
MI - melt index
15 Mn - number average molecular weight
Mw - weight average molecular weight
MW - molecular weight
N - norbornene
P - propylene
20 PE - polyethylene
PDI - polydispersity, M_w/M_n
PMAO - poly(methylaluminoxane)
Pr - propyl
RI - refractive index
25 rt - room temperature
S - styrene
TCB - 1,3,5-trichlorobenzene
THF - tetrahydrofuran
Tm - melting point
30 tmeda - N,N,N',N'-tetramethylethylenediamine
TO - turnovers, moles of monomer polymerized
per mole of catalyst (nickel compound) used

Examples 1-16Ligand Syntheses

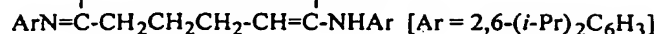
Ligand syntheses and deprotonations were carried out according to the general procedures given below unless stated otherwise. The general procedure for imine synthesis is based upon published procedures for the synthesis of N-aryl-substituted imines given in the following reference: Tom Dieck, H.; Svoboda, M.; Grieser, T. Z. *Naturforsch* **1981**, 36b, 823 - 832. The synthesis of $\text{ArN}=\text{CH}-\text{CH}(\text{t-Bu})-\text{N}(\text{Ar})(\text{Li})$ [$\text{Ar} = 2,6\text{-(i-Pr)}_2\text{C}_6\text{H}_3$] is based on the published synthesis of $(\text{t-Bu})\text{N}=\text{CH}-\text{CH}(\text{t-Bu})-\text{N}(\text{t-Bu})(\text{Li})$: Gardiner, M. G.; Raston, C. L. *Inorg. Chem.* **1995**, 34, 4206 - 4212. The synthesis of $\text{ArN}=\text{C}(\text{Me})-\text{CH}=\text{C}(\text{Me})-\text{NH}(\text{Ar})$ [$\text{Ar} = 2,6\text{-(i-Pr)}_2\text{C}_6\text{H}_3$] was published in WO Pat. Appl. 96/23010, and it was deprotonated according to the general procedure given below. The bis(pyrazolyl)borate anions that were used to synthesize complexes 18 and 19 were provided by S. Trofimenko (DuPont) and were synthesized according to the procedures published in the following review: Trofimenko, S. *Chem. Rev.* **1993**, 93, 943.

General Procedure for Imine Synthesis. In a fume hood, formic acid catalyst was added to a methanol solution of the aldehyde and the aniline (~1.1 - 1.2 equiv). The reaction mixture was stirred and the resulting precipitate was collected on a frit and washed with methanol. The product was then dissolved in Et_2O or CH_2Cl_2 and stirred over Na_2SO_4 overnight. The solution was filtered through a frit with Celite® and the solvent was removed in vacuo to yield the product.

General Procedure for the Synthesis of Sodium Salts. The protonated forms of the ligands were dissolved in anhydrous THF in the drybox. Solid NaH was slowly added to the solution, and then the reaction mixture was stirred overnight. The next day, the solution was filtered through a frit with dry Celite®. The solvent was removed and the resulting powder was

dried in vacuo. With some exceptions (e.g., Example 1), the sodium salts were not soluble in pentane and were further purified by a pentane wash.

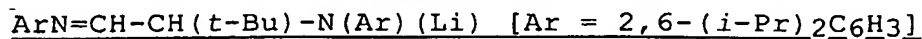
Example 1



A drop of formic acid was added to a solution of 1,2-cyclohexanedione (0.25 g, 2.2 mmol) and 2,6-diisopropylaniline (0.85 mL, 4.5 mmol) in 5 mL of methanol. The reaction mixture was stirred at rt for 3 days. The white solid thus formed was filtered, washed with a small amount of methanol and dried under vacuum. After recrystallization from hot methanol, the product (0.4 g; 41% yield; mp 81-83 °C) was isolated as white crystals: ¹H NMR (CDCl₃, 300 MHz, rt): δ 7.28 - 7.08 (m, 6, H_{aryl}), 6.45 (s, 1, NH), 4.84 (t, 1, J = 4.6, -CH=CNHAr), 3.30 (septet, 2, J = 6.88, CHMe₂), 2.86 (septet, 2, J = 6.87, C'HMe₂), 2.22 (m, 4, ArN=CCH₂CH₂-), 1.75 (m, 2, CH₂CH=CNHAr), 1.24 and 1.22 (d, 12 each, CHMe₂ and C'HMe₂); ¹³C NMR (CDCl₃, 300 MHz, rt) δ 162.1, 147.3, 145.8, 139.6, 137.0, and 136.4 (ArNH-C-C=NAr, Ar: C_{ipso}, C_O; Ar': C_{ipso}, C_O), 126.5, 123.4, 123.3 and 122.9 (Ar: C_p, C_m; Ar': C_p, C_m), 106.0 (ArNHC=CH-), 29.3, 28.4 and 28.3 (ArNHC=CH-CH₂CH₂CH₂C=NAr), 24.2 and 23.30 (CHMe₂, C'HMe₂), 23.25 and 22.9 (CHMe₂, C'HMe₂).

The sodium salt was cleanly synthesized according to the above general procedure: ¹H NMR (300 MHz, THF-dg): no THF coordinated.

Example 2



In a nitrogen-filled drybox, *t*-BuLi (7.81 mL of a 1.7 M solution in pentane) was filtered through a short plug of dry Celite® into a round bottom flask. The flask was cooled to -35 °C in the drybox freezer. The diimine ArN=CH-CH=NAr [Ar = 2,6-(*i*-Pr)₂C₆H₃] was added as a solid over a period of 15 min to the cold *t*-BuLi solution. The reaction mixture was stirred for ~2 h to give a viscous red solution. The solution was diluted

with pentane and then filtered through a frit with Celite®. The resulting clear solution was concentrated under vacuum and then cooled in the drybox freezer to -35°C . An orange powder was obtained (3.03 g, 51.8%, 1st crop): ^1H NMR (THF-*d*₈, 300 MHz, rt) δ 8.29 (s, 1, CH=N), 7.08 (d, 2, *J* = 7.4, Ar: H_m), 7.00 (t, 1, *J* = 7.0, Ar: H_p), 6.62 (m, 2, Ar: H_m), 6.14 (t, 1, *J* = 7.4, Ar: H_p), 4.45 (s, 1, CH(*t*-Bu)), 3.08 (br septet, 2, CHMe₂), 3.05 (septet, 2, *J* = 6.8, CHMe₂), 1.35 (d, 3, *J* = 6.7, CHMe₂), 1.13 (d, 3, *J* = 7.0, CHMe₂), 1.13 (br s, 12, CHMe₂), 1.02 (d, 3, *J* = 6.7, CHMe₂), 0.93 (s, 9, CMe₃); ^{13}C NMR (THF-*d*₈, 75 MHz, rt) δ 184.5 (N=CH), 161.9 and 150.1 (Ar, Ar': C_{ipso}), 139.7, 139.5 (br), 139.0 (br) and 137.3 (Ar, Ar': C_O), 125.0, 124.0, 123.5, 122.4 and 112.2 (Ar, Ar': C_m and C_p), 80.8 (CH(*t*-Bu)), 41.5 (CMe₃), 29.3, 28.6, 27.8 (br), 26.5 (br), 26.3, 25.9, 25.6, 25.0 and 23.3 (br) (Ar, Ar': CHMe₂; CMe₃).

Example 3

[2-(OH)-3,5-(*t*-Bu)₂C₆H₂]-CH=NAr [Ar = 2,6-(*i*-Pr)₂C₆H₃]

The general procedure for imine synthesis was followed using 10.1 g (43.0 mmol) of 3,5-di-*t*-butyl-2-hydroxybenzaldehyde and 9.91 g (55.9 mmol, 1.30 equiv) of 2,6-diisopropylaniline. A light yellow powder (10.5 g, 62.1%) was isolated: ^1H NMR (CDCl₃, 300 MHz, rt) δ 13.50 (s, 1, OH), 8.35 (s, 1, CH=NAr), 7.56 (d, 1, *J* = 2.7, H_{aryl}), 7.22 (m, 4, H_{aryl}), 3.08 (septet, 2, *J* = 6.8, CHMe₂), 1.55 (s, 9, CMe₃), 1.39 (s, 9, C'_{Me3}), 1.23 (d, 12, *J* = 6.7, CHMe₂).

The sodium salt was cleanly synthesized according to the above general procedure: ^1H NMR (300 MHz, THF-*d*₈): 0.63 equiv of THF coordinated.

Example 4

[2-(OH)-3,5-(t-Bu)₂C₆H₂]-CH=NAr [Ar = 2,6-Me₂C₆H₃]

The general procedure for imine synthesis was followed using 3.05 g (13.0 mmol) of
5 3,5-di-t-butyl-2-hydroxybenzaldehyde and 1.89 g (15.6 mmol, 1.20 equiv) of 2,6-dimethylaniline. A yellow powder (2.00 g, 45.6%) was isolated: ¹H NMR (CDCl₃, 300 MHz, rt, OH resonance not assigned) δ 8.34 (s, 1, CH=NAr), 7.50 and 7.16 (d, 1 each, H_{aryl}), 7.10 (d, 2, Ar: H_m), 7.01 (t, 1, Ar: H_p), 2.22 (s, 6, Ar: Me), 1.49 (s, 9, CMe₃), 1.34 (s, 9, C'Me₃).

The sodium salt was cleanly synthesized according to the above general procedure: ¹H NMR (300 MHz, THF-dg): 0.51 equiv of THF coordinated.

15

Example 5

[2-(OH)-3,5-(t-Bu)₂C₆H₂]-CH=NAr [Ar = 2,6-Br₂-4-F-C₆H₂]

The general procedure for imine synthesis was followed using 2.12 g (9.05 mmol) of
20 3,5-di-t-butyl-2-hydroxybenzaldehyde and 1.89 g (10.8 mmol, 1.20 equiv) of 2,6-dibromo-4-fluoroaniline. A yellow powder (1.11 g, 25.5%) was isolated: ¹H NMR (CDCl₃, 300 MHz, rt, OH resonance not assigned) δ 8.45 (s, 1, CH=NAr), 7.54 (d, 1, H_{aryl}), 7.40 (d, 2, J_{HF} ~9, Ar: H_m), 7.19 (d, 1, H_{aryl}), 1.50 (s, 9, CMe₃), 1.35 (s, 9, C'Me₃).

The sodium salt was cleanly synthesized according to the above general procedure: ¹H NMR (300 MHz, THF-dg): 0.58 equiv of THF coordinated.

25

Example 6

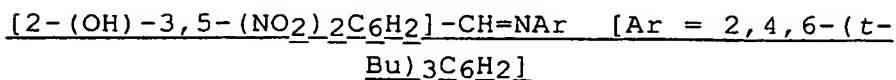
[2-(OH)-3,5-(NO₂)₂C₆H₂]-CH=NAr [Ar = 2,6-(i-Pr)₂C₆H₃]

The general procedure for imine synthesis was followed using 4.98 g (23.5 mmol) of
3,5-dinitro-2-hydroxybenzaldehyde and 4.16 g (23.5
35 mmol) of 2,6-diisopropylaniline. A yellow powder (6.38 g, 73.1%) was isolated: ¹H NMR (CDCl₃, 300 MHz, rt, OH resonance not assigned) δ 9.06 (d, 1, H_{aryl}), 8.52 (d, 1, H_{aryl}), 8.31 (d, 1, J ~ 6, CH=NAr), 7.40 (t, 1, Ar:

H_p), 7.30 (d, 2, Ar: H_m), 2.96 (septet, 2, $CHMe_2$), 1.25 (d, 12, $CHMe_2$).

The sodium salt was cleanly synthesized according to the above general procedure: 1H NMR (300 MHz, THF-
5 dg): 0.57 equiv of THF coordinated.

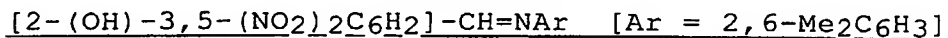
Example 7



The general procedure for imine synthesis was
10 followed using 3.00 g (14.1 mmol) of
3,5-dinitro-2-hydroxybenzaldehyde and 3.88 g (14.9
mmol, 1.06 equiv) of 2,4,6-tris(t-butyl)aniline. A
yellow powder (4.78 g, 74.5%) was isolated: 1H NMR
($CDCl_3$, 300 MHz, rt, OH resonance not assigned) δ 9.09
15 (d, 1, H_{aryl}), 8.41 (d, 1, H_{aryl}), 8.16 (d, 1, $J \sim 12$,
 $CH=NAr$), 7.48 (s, 1, Ar: H_m), 1.38 (s, 18, CMe_3), 1.36
(s, 9 $C'Me_3$).

The sodium salt was cleanly synthesized according
to the above general procedure: 1H NMR (300 MHz, THF-
20 dg): 2 equiv of THF coordinated.

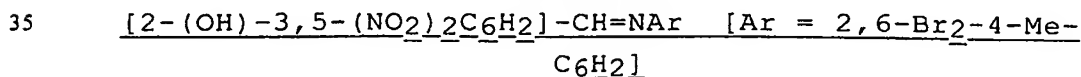
Example 8



The general procedure for imine synthesis was
followed using 3.11 g (14.7 mmol) of
25 3,5-dinitro-2-hydroxybenzaldehyde and 1.96 g (16.1
mmol, 1.10 equiv) of 2,6-dimethylaniline. A yellow
powder (3.63 g, 78.4%) was isolated: 1H NMR ($CDCl_3$,
300 MHz, rt, OH resonance not assigned) δ 9.05 (d, 1,
 H_{aryl}), 8.52 (d, 1, H_{aryl}), 8.42 (d, 1, $J \sim 9$, $CH=NAr$),
30 7.22 (m, 3, Ar: H_p and H_m), 2.36 (s, 6, Ar: Me).

The sodium salt was cleanly synthesized according
to the above general procedure: 1H NMR (300 MHz, THF-
dg): 0.25 equiv of THF coordinated.

Example 9



The general procedure for imine synthesis was
followed using 3.10 g (14.6 mmol) of 3,5-

dinitro-2-hydroxybenzaldehyde and 4.64 g (17.5 mmol, 1.20 equiv) of 2,6-dibromo-4-methylaniline. A yellow powder (5.15 g, ~76.8%) was isolated. The ¹H NMR spectrum of the product showed the presence of methanol, so the powder was dissolved in THF in the drybox under a nitrogen atmosphere and the solution was placed over molecular sieves for several days. The solution was then filtered through a frit with Celite® and the solvent was removed in vacuo: ¹H NMR (CDCl₃, 300 MHz, rt; OH resonance not assigned; ~ 1 equiv of THF is present) δ 8.95 (d, 1, J = 2.8, H_{aryl}), 8.76 (s, 1, CH=NAr), 8.71 (d, 1, J = 2.8, H_{aryl}), 7.43 (s, 2, Ar: H_m), 2.31 (s, 3, Ar: Me).

The sodium salt was cleanly synthesized according to the above general procedure: ¹H NMR (300 MHz, THF-dg): 3 equiv of THF coordinated.

Example 10

[2-Hydroxynaphthyl]-CH=NAr [Ar = 2,6-(i-Pr)₂C₆H₃]

The general procedure for imine synthesis was followed using 20.1 g (117 mmol) of 2-hydroxy-1-naphthaldehyde and 24.8 g (140 mmol, 1.20 equiv) of 2,6-diisopropylaniline. A yellow-gold powder (30.8 g, 79.5%) was isolated: ¹H NMR (CDCl₃, 300 MHz, rt) δ 15.30 (d, 1, OH), 9.15 (d, 1, CH=N), 8.08 (d, 1, H_{naphthyl}), 7.98 (d, 1, H_{naphthyl}), 7.88 (d, 1, H_{naphthyl}), 7.60 (t, 1, H_{naphthyl}), 7.45 (t, 1, H_{naphthyl}), 7.35 (m, 3, Ar: H_m and H_p), 7.29 (d, 1, H_{naphthyl}), 3.20 (septet, 2, CHMe₂), 1.33 (d, 12, CHMe₂).

The sodium salt was cleanly synthesized according to the above general procedure ¹H NMR (300 MHz, THF-dg): 0.5 equiv of THF coordinated.

Example 11

[2-Hydroxynaphthyl]-CH=NAr [Ar = 2,6-Me₂C₆H₃]

The general procedure for imine synthesis was followed using 33.7 g (196 mmol) of 2-hydroxy-1-naphthaldehyde and 28.4 g (235 mmol, 1.20 equiv) of 2,6-dimethylaniline. A golden yellow powder

(47.2 g, 87.5%) was isolated: ^1H NMR (CDCl_3 , 300 MHz, rt, OH resonance not assigned) δ 9.23 (d, 1, $\text{N}=\text{CH}$), 8.4 - 7.1 (m, 9, Haryl), 2.41 (s, 6, Ar: Me).

The sodium salt was cleanly synthesized according to the above general procedure: ^1H NMR (300 MHz, THF-dg): 0.5 equiv of THF coordinated.

Example 12

$[2-(\text{OH})-3,5-\text{Cl}_2\text{C}_6\text{H}_2]-\text{CH}=\text{NAr}$ [Ar = 2,6-(i-Pr) $_2\text{C}_6\text{H}_3]$

The general procedure for imine synthesis was followed using 8.67 g (45.4 mmol) of 3,5-dichloro-2-hydroxybenzaldehyde and 9.66 g (54.5 mmol, 1.20 equiv) of 2,6-diisopropylaniline. A light yellow powder (10.7 g, 67.3%) was isolated: ^1H NMR (CDCl_3 , 300 MHz, rt) δ 13.95 (s, 1, OH), 8.20 (s, 1, $\text{CH}=\text{NAr}$), 7.50 (d, 1, Haryl), 7.18 - 6.83 (m, 3, Haryl), 7.23 (d, 1, Haryl), 2.89 (septet, 2, CHMe_2), 1.16 (d, 12, CHMe_2); ^{13}C NMR (CDCl_3 , 75 MHz, rt) δ 165.1 ($\text{N}=\text{CH}$), 156.1, 145.0, 138.7, 132.9, 129.8, 128.6, 126.2, 123.4, 123.0 and 119.7 (Caryl), 28.3 (CHMe_2), 23.6 (CHMe_2).

The sodium salt was cleanly synthesized according to the above general procedure: ^1H NMR (300 MHz, THF-dg): 0.5 equiv of THF coordinated.

Example 13

$[2-(\text{OH})-3,5-\text{Cl}_2\text{C}_6\text{H}_2]-\text{CH}=\text{NAr}$ [Ar = 2,6-Me $_2\text{C}_6\text{H}_3]$

The general procedure for imine synthesis was followed using 16.2 g (85.0 mmol) of 3,5-dichloro-2-hydroxybenzaldehyde and 11.3 g (93.5 mmol, 1.10 equiv) of 2,6-dimethylaniline. A yellow powder (18.2 g, 72.7%) was isolated: ^1H NMR (CDCl_3 , 300 MHz, rt) δ 14.15 (s, 1, OH), 8.43 (s, 1, $\text{N}=\text{CH}$), 7.65 (d, 1, $J = 2.5$, Haryl), 7.41 (d, 1, $J = 2.5$, Haryl), 7.30 - 7.18 (m, 3, Ar: H_m and H_p), 2.35 (s, 6, Me).

The sodium salt was cleanly synthesized according to the above general procedure: ^1H NMR (300 MHz, THF-dg): 0.33 equiv of THF coordinated.

Example 14

[2-(OH)-5-(NO₂)C₆H₂]-CH=NAr [Ar = 2,6-(i-Pr)₂C₆H₃]

The general procedure for imine synthesis was followed using 5.22 g (31.2 mmol) of

5-nitro-2-hydroxybenzaldehyde and 6.65 g (37.5 mmol, 1.20 equiv) of 2,6-diisopropylaniline. A yellow powder (4.39 g, 43.1%) was isolated: ¹H NMR (CDCl₃, 300 MHz, rt, OH resonance not assigned) δ 8.38 (s, 1, CH=NAr), 8.35 (d, 1, J = 3, H'_m to hydroxy), 8.30 (dd, 1, J = 9, 3, H_m to hydroxy), 7.23 (s, 3, Ar: H_m and H_p), 7.15 (d, 1, J = 9, H_o to hydroxy), 2.93 (septet, 2, CHMe₂), 1.20 (s, 12, CHMe₂).

The sodium salt was cleanly synthesized according to the above general procedure: ¹H NMR (300 MHz, THF-dg): 0.25 equiv of THF coordinated.

Example 15

Pyrrole-2-(CH=NAr) [Ar = 2,6-(i-Pr)₂C₆H₃]

The general procedure for imine synthesis was followed using 5.00 g (52.6 mmol) of

pyrrole-2-carboxaldehyde and 10.3 g (57.9 mmol, 1.1 equiv) of 2,6-diisopropylaniline. The compound was isolated as an off-white powder: ¹H NMR (CDCl₃, 300 MHz, rt) δ 10.96 (s, 1, NH), 8.05 (s, 1, N=CH), 7.26 (s, 3, Ar: H_m, H_p), 6.68, 6.29 and 6.24 (m, 1 each, H_{pyrrole}), 3.17 (septet, 2, J = 6.9, CHMe₂), 1.20 (d, 12, J = 7.2, CHMe₂); ¹³C NMR (CDCl₃, 75 MHz, rt) δ 152.6 (N=CH), 148.5, 138.9 and 129.9 (pyrrole: C_{ipso}; Ar: C_{ipso}, C_o), 124.5, 124.0, 123.2, 116.5 and 109.9 (pyrrole: 3 CH carbons and Ar: C_m, C_p), 27.9 (CHMe₂), 23.6 (CHMe₂).

The sodium salt was cleanly synthesized according to the above general procedure: ¹H NMR (300 MHz, C₆D₆/THF-dg): 1 equiv of THF coordinated.

Example 16

(Ar) (H)N-C(Me)=CH-C(O)OMe [Ar = 2,6-(i-Pr)₂C₆H₃]

Concentrated HCl (2 drops) was added to a solution of methylacetoacetate (5.2 mL; 48.5 mmol) and 2,6-diisopropylaniline (8.58 g, 48.5 mmol) in methanol.

The reaction mixture was stirred at room temperature for 30 h. The product (5.95 g; 45% yield; mp 125-127°C) was filtered, washed with a small amount of methanol, and then dried under vacuum. Additional
5 product (3.79 g, 28%; mp 115-122°C) was isolated from the mother liquor: ¹H NMR (300 MHz, CDCl₃, rt): δ 9.78 (br s, 1, NH), 7.29 (t, 1, J = 8.1, Ar: H_p), 7.17 (d, 2, J = 8.2, Ar: H_m), 4.71 (s, 1, =CH), 3.70 (s, 3, OMe), 3.10 (septet, 2, J = 6.8, CHMe₂), 1.61 (s, 3, =CMe),
10 =CMe), 1.22 (d, 6, J = 6.8, CHMeMe'), 1.1.5 (d, 6, J = 6.7, CHMeMe').

The sodium salt was cleanly synthesized according to the above general procedure: ¹H NMR (300 MHz, THF-dg): no THF coordinated.

15

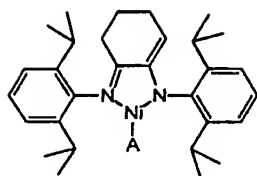
Examples 17 - 40

Synthesis of Nickel Complexes

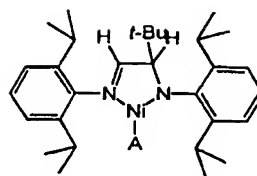
General Synthesis of Nickel Allyl Initiators. A mixture of two equiv of the appropriate anionic ligand and one equiv of [(allyl)Ni(μ-X)]₂ (X = Cl or Br) was
20 dissolved in THF. The reaction mixture was stirred for several h before being filtered. The solvent was removed in vacuo to yield the desired product. Depending on the solubility of the product, further purification was often carried out by dissolving the
25 product in Et₂O or pentane and filtering again or washing the product with Et₂O or pentane. Due to ease of characterization and, especially, ease of initiation in the presence of a Lewis acid, typically allyl = (a) H₂CC(CO₂Me)CH₂. However, other allyl derivatives were
30 also synthesized and their polymerization activity explored; these include allyl = (b) H₂CCHCH₂, (c) H₂CCHCHMe, (d) H₂CCHCMe₂, (f) H₂CCHCHCl, and (g) H₂CCHCHPh. The [(allyl)Ni(μ-X)]₂ precursors were synthesized according to the procedures published in
35 the following reference: Wilke, G.; Bogdanovic, B.; Hardt, P.; Heimbach, P.; Keim, W.; Kroner, M.; Oberkirch, W.; Tanaka, K.; Steinrucke, E.; Walter, D.;

Zimmermann, H. *Angew. Chem. Int. Ed. Engl.* **1966**, 5,
151-164.

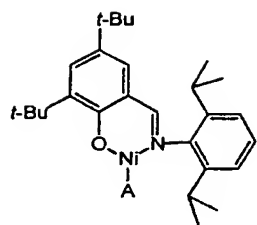
Complexes **1 - 20** were synthesized according to the
above general procedure and their structures, syntheses
5 and characterization follow:



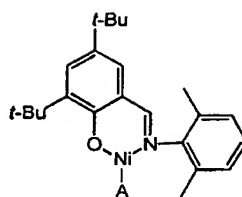
1



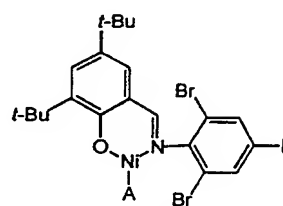
2



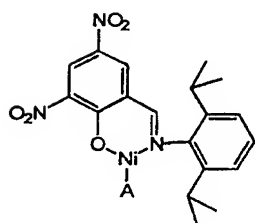
3



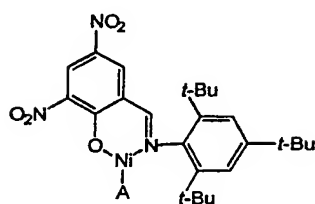
4



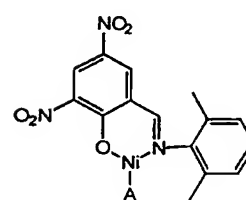
5



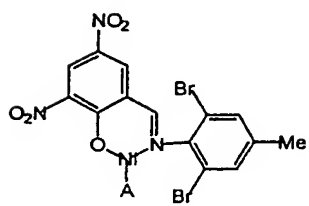
6



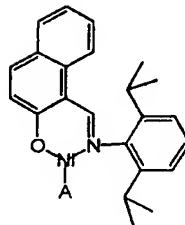
7



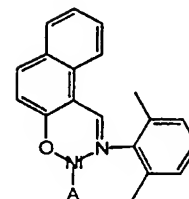
8



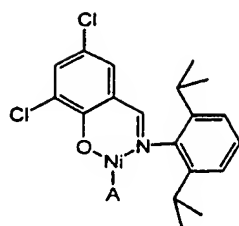
9



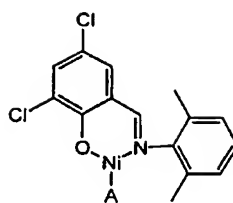
10



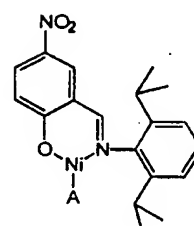
11



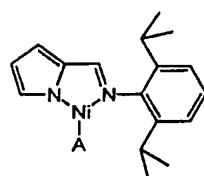
12



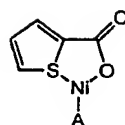
13



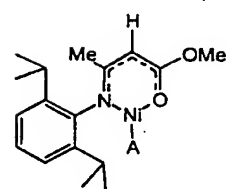
14



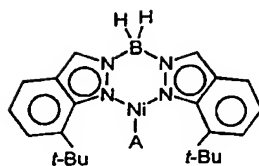
15



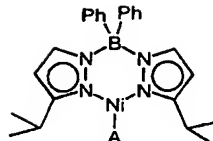
16



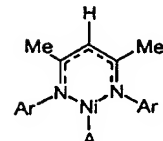
17



18



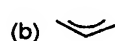
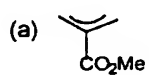
19



Ar = 2,6-(*i*-Pr₂)C₆H₃

20

A (Allyl)



Example 17

Complex 1a. Two equiv (610 mg, 1.35 mmol) of the sodium salt of the ligand were reacted with one equiv (321 mg, 0.674 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 655 mg (82.6% yield) of a deep purple powder.

Example 18

Complex 1d. Two equiv (667 mg, 1.47 mmol) of the sodium salt of the ligand were reacted with one equiv (306 mg, 0.737 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CCHCMe}_2$) to give a purple solid: ^1H NMR (C_6D_6 , 300 MHz, rt, $\text{H}_2\text{CCHCMe}_2$ resonances not assigned) δ 7.25 - 6.79 (m, 6, Haryl), 4.93 (t, 1, $J = 4.6$, $\text{ArNHC}=\text{CH}-$), 4.56 (br m, 1, $\text{H}_2\text{CCHCMe}_2$), 3.48 (septet, 2, $J = 6.9$, CHMe_2), 2.99 (septet, 2, $J = 6.9$, $\text{C}'\text{HMe}_2$), 2.07 (m, 2, Cy: CH_2), 1.92 (m, 2, Cy: CH_2), 1.42 (m, 2, Cy: CH_2), 1.2 - 1.1 (doublets, 24, CHMe_2 , $\text{C}'\text{HMe}_2$), 0.72 and 0.61 (br s, 3 each, $\text{H}_2\text{CCHCMeMe}'$).

Example 19

Complex 2a. Two equiv (1.08 g, 2.44 mmol) of the lithium salt of the ligand were reacted with one equiv (581 mg, 1.22 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to yield 1.35 g (93.8% yield) of a red powder. ^1H NMR spectrum in C_6D_6 is complex.

Example 20

Complex 3a. Two equiv (4.01 g, 8.71 mmol) of the sodium salt of the ligand were reacted with one equiv (2.07 g, 4.35 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to yield 3.61 g (75.2% yield) of a golden yellow powder. ^1H NMR (C_6D_6 , 300 MHz, rt) δ 7.84 (s, 1, $\text{N}=\text{CH}$), 7.44 and 6.92 (d, 1 each, Haryl), 7.20 (m, 3, Ar: H_m , H'_m and H_p), 3.88 (d, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 3.86 (septet, 1, CHMe_2), 3.80 (s, 3, OMe), 3.04 (septet, 1, $\text{C}'\text{HMe}_2$), 2.91 (s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 1.89 (m, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 1.43 (s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 1.41 and 1.25 (s, 9 each, CMe_3 and $\text{C}'\text{Me}_3$), 1.37, 1.27, 1.16 and 1.02 (d, 3 each, CHMeMe' and $\text{C}'\text{HMeMe}'$); ^{13}C NMR (CD_2Cl_2 , 75 MHz, rt) δ

166.6 (N=CH), 167.4, 164.7, 153.0, 141.3, 140.9, 139.9, 136.5, 117.7 and 110.9 (H₂CC(CO₂Me)CH₂; Ar: Cipso, Co, C'_o; Ar': Cipso, Co, C_m, C'_m), 130.2, 127.9, 126.8, 124.0 and 123.9 (Ar: C_m, C'_m, C_p; Ar': C_p and C'_o), 59.8 and 47.0 (H₂CC(CO₂Me)CH₂), 53.1 (CO₂Me), 35.9 and 34.3 (CMe₃ and C'Me₃), 31.6 and 30.0 (CMe₃ and C'Me₃), 29.0, 28.5, 25.7, 25.6, 23.3 and 22.7 (CHMeMe' and C' HMeMe').

Single crystals were formed by cooling a pentane solution of the complex to -35°C in the drybox freezer. The structure of the compound was solved by X-ray crystallography and is in agreement with the proposed structure.

Example 21

15 Complex 4a. Two equiv (834 mg, 2.11 mmol) of the sodium salt of the ligand were reacted with one equiv (501 mg, 1.05 mmol) of [(allyl)Ni(μ-Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 935 mg (89.7% yield) of a golden yellow powder: ¹H NMR (THF-d₈, 300 MHz, rt) δ 7.94 (s, 1, N=CH), 7.40 (d, 1, H_{aryl}), 7.13 - 6.92 (m, 3, Ar: H_m, H'_m, H_p), 7.00 (d, 1, H_{aryl}), 3.78 (s, 3, OMe), 3.76 (d, 1, HH'CC(CO₂Me)CHH'), 2.80 (s, 1, HH'CC(CO₂Me)CHH'), 2.45 (s, 3, Ar: Me), 2.10 (s, 3, Ar: Me'), 1.85 (d, 1, HH'C(CO₂Me)CHH'), 1.60 (t, 1, HH'CC(CO₂Me)CHH'), 1.40 and 1.24 (s, 9 each, CMe₃ and C'Me₃); ¹³C NMR (CD₂Cl₂, 75 MHz, rt) δ 166.2 (N=CH), 167.3, 164.3, 155.1, 141.1, 136.2, 130.0, 129.4, 118.0 and 110.3 (H₂CC(CO₂Me)CH₂, Ar: Cipso, Co, C'_o; Ar': Cipso, Co, C_m, C'_m), 129.8, 128.5, 128.4, 127.8 and 125.6 (Ar: C_m, C'_m, C_p; Ar': C_p, C'_o), 57.8 and 47.7 (H₂CC(CO₂Me)CH₂), 52.8 (OMe), 35.7 and 34.1 (CMe₃ and C'Me₃), 31.4 and 29.4 (CMe₃ and C'Me₃), 19.0 and 18.4 (Ar: Me and Me').

Example 22

35 Complex 5a. Two equiv (390 mg, 0.709 mmol) of the sodium salt of the ligand were reacted with one equiv (169 mg, 0.355 mmol) of [(allyl)Ni(μ-Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 189 mg (45.8% yield) of a

golden yellow powder: ^1H NMR (CDCl_3 , 300 MHz, rt, broad resonances) δ 7.80 (br s, 1, $\text{N}=\text{CH}$), 7.50 (br s, 1, Haryl), 7.42 (br s, 1, Ar: H_m , H'_m), 6.96 (br s, 1, Haryl), 3.92 (br s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 3.86 (br s, 3, OMe), 2.84 (br s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 1.98 and 1.76 (br s, 1 each, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 1.43 and 1.29 (br s, 9 each, CMe_3 and $\text{C}'\text{Me}_3$).

Example 23

Complex 6a. Two equiv (900 mg, 2.10 mmol) of the sodium salt of the ligand were reacted with one equiv (500 mg, 1.05 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 864 mg (77.9% yield) of a golden yellow powder: ^1H NMR (C_6D_6 , 300 MHz, rt) δ 8.40 (d, 1, $\text{J} = 3.0$, Haryl), 7.66 (d, 1, $\text{J} = 3.0$, Haryl), 7.12 (s, 1, $\text{N}=\text{CH}$), 7.10 - 6.90 (m, 3, Ar: H_m , H'_m , H_p), 4.05 (m, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 3.49 (septet, 1, $\text{J} = 6.9$, CHMe_2), 3.21 (s, 3, OMe), 2.96 (septet, 1, $\text{J} = 6.8$, $\text{C}'\text{HMe}_2$), 2.67 (s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 2.23 (m, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 1.34 (br s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 1.36, 1.15, 0.95 and 0.84 (d, 3 each, $\text{J} = 6.8$, CHMeMe' , $\text{C}'\text{HMeMe}'$).

Example 24

Complex 6f. Two equiv (267 mg, 0.621 mmol) of the sodium salt of the ligand were reacted with one equiv (105 mg, 0.310 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Cl})]_2$ (allyl = $\text{H}_2\text{CCHCHCl}$) to give 245 mg (78.3% yield) of a golden yellow powder: ^1H NMR spectrum in C_6D_6 is complex.

Example 25

Complex 7a. Two equiv (926 mg, 1.49 mmol) of the sodium salt of the ligand were reacted with one equiv (354 mg, 0.745 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 861 mg (94.4% yield) of a golden yellow powder: ^1H NMR (C_6D_6 , 300 MHz, rt) δ 8.43 (d, 1, $\text{J} = 2.6$, Haryl), 7.81 (d, 1, $\text{J} = 2.9$, Haryl), 7.48 (s, 2, Ar: H_m), 7.45 (s, 1, $\text{N}=\text{CH}$), 4.12 (d, 1, $\text{J} = 2.9$, $\text{HH}'\text{C}(\text{CO}_2\text{Me})\text{CHH}'$), 3.28 (s, 3, OMe), 2.84 (s, 1, $\text{HH}'\text{C}(\text{CO}_2\text{Me})\text{CHH}'$), 2.44 (t, 1, $\text{J} = 2.4$, $\text{HH}'\text{C}(\text{CO}_2\text{Me})\text{CHH}'$), 1.58, 1.41 and 1.28 (s, 9 each, CMe_3 ,

$C'Me_3$, $C''Me_3$), 1.31 (d, 1, $J = 1.1$, $HH'C(CO_2Me)CHH'$);
 ^{13}C NMR (C_6D_6 , 75 MHz, rt) δ 166.4 (N=CH), 165.5,
 162.9, 151.0, 148.1, 144.9, 139.4, 138.8, 134.21, 120.5
 and 113.4 ($H_2CC(CO_2Me)CH_2$; Ar: Cipso, Co, $C'o$, Cp; Ar':
 5 Cipso, Co, Cm, $C'm$), 134.16, 126.1, 125.1 and 124.7
 (Ar: Cm, $C'm$ and Ar': Cp and $C'o$), 63.3 and 49.0
 ($H_2C(CO_2Me)CH_2$), 52.4 (OMe), 37.2 (CMe_3), 34.8, 34.4
 and 31.4 (CMe_3 , $C'Me_3$ and $C''Me_3$), ($C'Me_3$ and $C''Me_3$
 overlap with CMe_3 or CMe_3 or $C'Me_3$ resonances).

10

Example 26

Complex 8a. Two equiv (529 mg, 1.49 mmol) of the
 sodium salt of the ligand were reacted with one equiv
 (354 mg, 0.745 mmol) of $[(allyl)Ni(\mu-Br)]_2$ (allyl =
 $H_2CC(CO_2Me)CH_2$) to give 662 mg (94.1% yield) of a
 15 golden yellow powder: 1H NMR (CD_2Cl_2 , 300 MHz, rt) δ
 8.80 (d, 1, Haryl), 8.40 (d, 1, Haryl), 8.08 (s, 1,
 N=CH), 7.14 (m, 3, Ar: H_m , $H'm$, H_p), 3.82 (d, 1,
 $HH'CC(CO_2Me)CHH'$), 3.88 (s, 3, OMe), 3.00 (s, 1,
 $HH'C(CO_2Me)CHH'$), 2.46 (s, 3, Ar: Me), 2.16 (m, 1,
 20 $HH'CC(CO_2Me)CHH'$), 2.14 (s, 3, Ar: Me'), 1.91 (s, 1,
 $HH'CC(CO_2Me)CHH'$).

Example 27

Complex 9a. Two equiv (1.46 g, 2.09 mmol) of the
 sodium salt of the ligand were reacted with one equiv
 25 (497 mg, 1.05 mmol) of $[(allyl)Ni(\mu-Br)]_2$ (allyl =
 $H_2CC(CO_2Me)CH_2$) to give 1.42 g (96.0% yield) of a red
 powder: 1H NMR (CD_2Cl_2 , 300 MHz, rt) δ 8.79 (d, 1,
 Haryl), 8.44 (d, 1, Haryl), 8.06 (s, 1, N=CH), 7.51 and
 7.49 (s, 1 each, Ar: H_m , $H'm$), 3.96 (d, 1,
 30 $HH'CC(CO_2Me)CHH'$), 3.85 (s, 3, OMe), 3.65 (br s, ~ 1.25
 equiv THF), 3.00 (s, 1, $HH'CC(CO_2Me)CHH'$), 2.37 (s, 3,
 Ar: Me), 2.23 (m, 1, $HH'CC(CO_2Me)CHH'$), 2.13 (s, 1,
 $HH'CC(CO_2Me)CHH'$), 1.85 (br s, ~ 1.25 equiv THF); ^{13}C
 NMR (CD_2Cl_2 , 75 MHz, rt) δ 168.3 (N=CH), 166.0, 163.6,
 35 148.9, 142.7, 140.5, 134.3, 122.0, 117.3, 116.7 and
 114.8 ($H_2CC(CO_2Me)CH_2$; Ar: Cipso, Co, $C'o$, Cp; Ar':
 Cipso, Co, Cm, $C'm$), 136.1, 133.5, 133.5 and 126.3 (Ar:
 Cm, $C'm$; Ar': Cp, $C'o$); 72.6 (br, THF), 61.2 and 51.4

(H₂CC(CO₂Me)CH₂), 53.6 (OMe), 34.9 (br, THF), 20.8 (Ar: Me).

Example 28

Complex 10a. Two equiv (490 mg, 1.3 mmol) of the sodium salt of the ligand were reacted with one equiv (300 mg, 0.63 mmol) of [(allyl)Ni(μ-Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 259 mg (~41% yield) of a yellow-green powder. About 12.5% of the isolated sample consists of a second species whose NMR spectrum is consistent with a (ligand)₂Ni(II) complex. The remainder is the allyl complex: ¹H NMR (C₆D₆, 300 MHz, rt) δ 8.75 (s, 1, N=CH), 7.50 - 6.90 (m, 8, H_{aryl}), 6.03 (d, 1, J = 9.2, H_{aryl}), 4.16 (d, 1, J = 3.0, HH'CC(CO₂Me)CHH'), 3.92 (septet, 1, J = 6.9, CHMe₂), 3.33 (s, 3, OMe), 3.27 (septet, 1, J = 6.8, C'HMe₂), 2.83 (s, 1, HH'CC(CO₂Me)CHH'), 2.77 (dd, 1, J = 3.4, 1.6, HH'CC(CO₂Me)CHH'), 1.47 (dd, 1, J = 1.5, 0.9, HH'CC(CO₂Me)CHH'), 1.36, 1.20, 1.02 and 0.92 (d, 3 each, J = 6.5 - 6.8, CHMeMe', C'HMeMe'). [Proposed (ligand)₂Ni(II) complex: δ 8.19 (s, 2, N=CH), 7.50 - 6.90 (m, 16, H_{aryl}), 6.12 (d, 2, H_{aryl}), 4.54 (septet, 4, J = 6.98, CHMe₂), 1.53 (d, 12, J = 6.8 CHMeMe'), 1.18 (d, 12, CHMeMe').]

Example 29

Complex 11a. Two equiv (487 mg, 1.32 mmol) of the sodium salt of the ligand were reacted with one equiv (314 mg, 0.660 mmol) of [(allyl)Ni(μ-Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 351 mg (~61.5% yield) of a yellow-green powder. About 17% of the isolated product consists of a second species whose NMR spectrum is consistent with a (ligand)₂Ni(II) complex; the remainder is the allyl complex: ¹H NMR (C₆D₆, 300 MHz, rt) δ 8.64 (s, 1, N=CH), 7.41 - 6.93 (m, 8, H_{aryl}), 6.05 (d, 1, J = 9.2, H_{aryl}), 4.07 (d, 1, J = 3.3, HH'CC(CO₂Me)CHH'), 3.30 (s, 3, OMe), 2.65 (s, 1, HH'CC(CO₂Me)CHH'), 2.28 (s, 3, Ar: Me), 2.16 (s, 4, Ar: Me' and HH'CC(CO₂Me)CHH'), 1.41 (br s, 1,

HH'CC(CO₂Me)CHH'. [Proposed (ligand)₂Ni complex: δ 8.01 (s, 2, N=CH), 2.66 (s, 12, Ar: Me).]

Example 30

Complex 11b. Two equiv (179 mg, 0.484 mmol) of the sodium salt of the ligand were reacted with one equiv (101 mg, 0.242 mmol) of [(allyl)Ni(μ -Br)]₂ (allyl = H₂CCHCMe₂) to give an orange-yellow powder (176 mg, 90.4%): ¹H NMR (C₆D₆, 300 MHz, rt) δ 8.65 (s, 1, N=CH), 7.48 - 6.94 (m, 9, H_{aryl}), 5.14 (dd, 1, J = 13.0, 7.9, H₂CCHCMe₂), 2.34 (s, 3, Ar: Me), 2.08 (s, 3, Ar: Me'), 1.40 (d, 1, J = 7.7, HH'CCHCMe₂), 1.36 (d, 1, J = 13.1, HH'CCHCMe₂), 1.13 and 1.02 (s, 3 each, H₂CCHCMeMe').

Example 31

Complex 12a. Two equiv (862 mg, 2.11 mmol) of the sodium salt of the ligand were reacted with one equiv (501 mg, 1.05 mmol) of [(allyl)Ni(μ -Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 951 mg (~88.8% yield) of a yellow-green powder. About 10% of the isolated product consists of a second species whose NMR spectrum is consistent with a (ligand)₂Ni(II) complex; the remainder is the allyl complex: ¹H NMR (C₆D₆, 300 MHz, rt) δ 7.40 (s, 1, N=CH), 7.38 - 6.98 (m, 5, H_{aryl}), 4.13 (d, 1, J = 2.9, HH'CC(CO₂Me)CHH'), 3.61 (septet, 1, J = 6.9, CHMe₂), 3.27 (s, 3, OMe), 3.03 (septet, 1, J = 6.8, C'HMe₂), 2.78 (s, 1, HH'CC(CO₂Me)CHH'), 2.16 (t, 1, J = 1.7, HH'CC(CO₂Me)CHH'), 1.38 (br s, 1, HH'CC(CO₂Me)CHH'), 1.34, 1.16, 0.94 and 0.83 (d, 3 each, J = 6.6 - 7.0, CHMeMe', C'HMeMe'); ¹³C NMR (C₆D₆, 75 MHz, rt, diagnostic resonances) δ 165.2 (N=CH), 61.9 and 48.7 (H₂CC(CO₂Me)CH₂), 52.3 (OMe), 28.7 and 28.4 (CHMe₂; C'HMe₂), 25.3, 25.3, 22.8 and 22.6 (CHMeMe', C'HMeMe'). [Proposed (ligand)₂Ni complex: ¹H NMR (C₆D₆) δ 7.20 - 6.36 (m, 12, N=CH and H_{aryl}), 4.49 (septet, 4, J = 6.9, CHMe₂), 1.42 and 1.13 (d, 12 each, J = 7.0, CHMeMe'); ¹³C NMR (C₆D₆) δ 29.6: (CHMe₂), 24.4 and 23.6 (CHMeMe').]

Example 32

Complex 13a. Two equiv (491 mg, 1.26 mmol) of the sodium salt of the ligand were reacted with one equiv (300 mg, 0.632 mmol) of [(allyl)Ni(μ -Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 469 mg (~82.4% yield) of a green powder. ~13% of the isolated product consists of a second species whose NMR spectrum is consistent with a (ligand)₂Ni(II) complex; the remainder is the allyl complex: ¹H NMR (C₆D₆, 300 MHz, rt) δ 7.37 (d, 1, J = 2.6, H_{aryl}), 6.98 (s, 1, N=CH), 6.98 - 6.86 (m, 3, H_{aryl}), 6.56 (d, 1, J = 2.0, H_{aryl}), 4.05 (d, 1, J = 2.6, HH'CC(CO₂Me)CHH'), 3.23 (s, 3, OMe), 2.60 (s, 1, HH'CC(CO₂Me)CHH', overlaps with Ar: Me of dimer), 2.09 and 2.03 (s, 3 each, Ar: Me, Me'), 2.06 (m, 1, HH'CC(CO₂Me)CHH'), 1.31 (s, 1, HH'CC(CO₂Me)CHH'). [Proposed (ligand)₂Ni(II) complex: δ 2.60 (s, Ar: Me).]

Example 33

Complex 14a. Two equiv (772 mg, 2.11 mmol) of the sodium salt of the ligand were reacted with one equiv (501 mg, 1.05 mmol) of [(allyl)Ni(μ -Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 891 mg (87.4% yield) of a yellow-orange powder: ¹H NMR (CD₂Cl₂, 300 MHz, rt) δ 8.25 (d, 1, Ar': H_O), 8.16 (dd, 1, Ar': H_P), 7.98 (s, 1, N=CH), 7.24 (m, 3, Ar: H_m, H'_m, H_P), 6.90 (d, 1, Ar': H_m), 3.92 (d, 1, HH'CC(CO₂Me)CHH'), 3.86 (s, 3, OMe), 2.99 (septet, 1, CHMe₂), 3.02 (s, 1, HH'CC(CO₂Me)CHH'), 2.98 (septet, 1, C'HMe₂), 2.08 (m, 1, HH'CC(CO₂Me)CHH'), 1.66 (t, 1, HH'CC(CO₂Me)CHH'), 1.39, 1.31, 1.17 and 1.01 (d, 3 each, CHMeMe' and C'HMeMe').

Example 34

Complex 15a. Two equiv (1.09 g, 3.13 mmol) of the sodium salt of the ligand were reacted with one equiv (743 mg, 1.56 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 858 mg (66.7% yield) of a yellow-orange powder: ^1H NMR (C_6D_6 , 300 MHz, rt) δ 7.20 - 7.00 (m, 5, $\text{N}=\text{CH}$; Ar: H_m , H'_m , H_p ; $\text{H}_{\text{pyrrole}}$), 6.77 (m, 1, $\text{H}_{\text{pyrrole}}$), 6.42 (m, 1, $\text{H}_{\text{pyrrole}}$), 3.84 (m, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 3.65 (septet, 1, $\text{J} = 6.8$, CHMe_2), 3.30 (s, 3, OMe), 3.19 (septet, 1, $\text{J} = 6.9$, $\text{C}'\text{HMe}_2$), 2.85 (m, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 2.20 (d, 1, $\text{J} = 0.89$; $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 1.89 (d, 1, $\text{J} = 0.89$, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 1.24, 1.18, 1.05 and 0.92 (d, 3 each, $\text{J} = 6.8 - 7.1$, CHMeMe' , $\text{C}'\text{HMeMe}'$); ^{13}C NMR (C_6D_6 , 75 MHz, rt) δ 162.5 ($\text{N}=\text{CH}$), 166.2, 148.7, 141.5, 141.4, 141.3, 140.8, 126.5, 123.43, 123.39, 118.8, 114.0 and 109.6 ($\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$; C_{aryl} ; $\text{C}_{\text{pyrrole}}$), 54.0 and 50.3 ($\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$), 52.1 (OMe), 28.4 and 28.3 (CHMe_2 , $\text{C}'\text{HMe}_2$), 25.1, 24.9, 23.0 and 22.5 (CHMeMe' and $\text{C}'\text{HMeMe}'$).

Example 35

Complex 16a. Two equiv (323 mg, 2.15 mmol) of the sodium salt of the ligand were reacted with one equiv (511 mg, 1.07 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 322 mg (62.6% yield) of an off-white (slightly red) powder.

Example 36

Complex 17a. Two equiv (987 mg, 3.32 mmol) of the sodium salt of the ligand were reacted with one equiv (789 mg, 1.66 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 1.14 g (79.4% yield) of a bright yellow-orange powder: ^1H NMR (C_6D_6 , 300 MHz, rt) δ 7.06 (br s, 3, H_{aryl}), 4.86 (d, 1, $\text{J} = 1.2$, $\text{ArNC}(\text{Me})\text{CHCO}_2\text{Me}$), 4.04 (septet, 1, $\text{J} = 6.7$, CHMe_2), 3.90 (d, 1, $\text{J} = 3.0$, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 3.37 and 3.36 (s, 3 each, (OMe)allyl and (OMe)ligand), 3.24 (septet, 1, $\text{J} = 7.0$, $\text{C}'\text{HMe}_2$), 2.66 (s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 2.01 (m, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 1.44 (s, 3,

ArNC(Me)CHCO₂Me), 1.36, 1.29, 1.17 and 1.03 (d, 3 each, J = 6.2 - 6.9, CHMeMe', C'HMeMe'), 1.14 (br s, 1, HH'CC(CO₂Me)CHH'); ¹³C NMR (C₆D₆, 75 MHz, rt) δ 170.5, 169.4, 166.7, 151.5, 147.3, 141.1, 140.1, 125.4, 123.7 and 109.2 (Ar: Cipso, Co, Co', Cm, Cm', Cp; H₂CC(CO₂Me)CH₂; ArNC(Me)CHCO₂Me), 80.2 (ArNC(Me)CHCO₂Me), 60.8 and 46.3 (H₂CC(CO₂Me)CH₂), 52.0 and 50.9 (H₂CC(CO₂Me)CH₂, ArNC(Me)CHCO₂Me), 28.4 and 28.1 (CHMe₂, C'HMe₂), 24.5, 24.3, 24.3 and 23.6 (CHMeMe', C'HMeMe'), 23.2 (ArNC(Me)CHCO₂Me).

Example 37

Complex 18a. Two equiv (1.20 g, 2.14 mmol) of the thallium salt of the ligand were reacted with one equiv (508 mg, 1.07 mmol) of [(allyl)Ni(μ-Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 730 mg (72.2% yield) of a red powder: ¹H NMR spectrum in C₆D₆ is complex.

Example 38

Complex 19a. Two equiv (435 mg, 1.03 mmol) of the potassium salt of the ligand were reacted with one equiv (245 mg, 0.514 mmol) of [(allyl)Ni(μ-Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 309 mg (60.4% yield) of a golden yellow powder. Some impurities are present, but the majority of the product is the allyl complex: ¹H NMR (CD₂Cl₂, 300 MHz, rt) δ 7.44 (s, 2, Hpyrazole), 7.4 - 7.0 (m, 10, Haryl), 6.00 (s, 2, Hpyrazole), 3.91 (s, 3, OMe), 3.50 (s, 2, HH'CC(CO₂Me)CHH'), 2.96 (septet, 2, J = 6.8, CHMe₂), 1.27 (d, 6, J = 7.0, CHMeMe'), 1.19 (d, 6, J = 7.0, CHMeMe'), 0.90 (s, 2, HH'CC(CO₂Me)CHH').

Example 39

Complex 20a. Two equiv (583 mg, 1.32 mmol) of the sodium salt of the ligand were reacted with one equiv (315 mg, 0.662 mmol) of [(allyl)Ni(μ-Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 407 mg (53.6% yield) of a bright yellow-green powder: ¹H NMR (C₆D₆, 300 MHz, rt) δ 7.11 (m, 6, Haryl), 5.04 (s, 1, NC(Me)C(H)C(Me)N), 4.04 (septet, 2, CHMe₂), 3.40 (septet, 2, C'HMe₂), 3.35 (s, 3, OMe), 2.29 (s, 2, HH'CC(CO₂Me)CHH'), 1.95 (s, 2,

HH'CC(CO₂Me)CHH'), 1.62 (s, 6, NC(Me)C(H)C(Me)N), 1.38, 1.32, 1.20 and 1.07 (d, 6 each, CHMeMe', C'HMeMe').

Example 40

Complex 20b. Two equiv (296 mg, 0.672 mmol) of the sodium salt of the ligand were reacted with one equiv (90.8 mg, 0.336 mmol) of [(allyl)Ni(μ -Cl)]₂ (allyl = H₂CCHCH₂) to give 151 mg (43.4% yield) of a bright yellow-orange powder: ¹H NMR (C₆D₆, 300 MHz, rt) δ 7.14 - 7.02 (m, 6, Haryl), 5.84 (m, 1, H₂CCHCH₂), 5.04 (s, 1, NC(Me)C(H)C(Me)N), 4.05 (septet, 2, J = 6.9, CHMe₂), 3.43 (septet, 2, J = 6.9, C'HMe₂), 1.79 (d, 2, J = 12.8, HH'CCHCHH'), 1.64 (s, 6, NC(Me)C(H)C(Me)N), 1.53 (d, 2, J = 6.8, HH'CCHCHH'), 1.39 1.29, 1.21 and 1.10 (d, 6 each, J = 6.8 - 7.1, CHMeMe', C'HMeMe').

Examples 41 - 130

Ethylene and Propylene Polymerization Procedures and Reactions

The results of ethylene and propylene polymerizations catalyzed by complexes 1-20 under various reaction conditions (see general procedures and Table 1 below) are reported in Tables 2-5. The polymers were characterized by NMR, GPC, and DSC analysis. A description of the methods used to analyze the amount and type of branching in polyethylene samples by ¹³C NMR spectroscopy is given in WO Pat. Appl. 96/23010. GPC's were run in trichlorobenzene at 135°C and calibrated against polystyrene standards.

General Procedure for the Screening of Ethylene Polymerizations by Nickel Allyl Initiators at 6.9 MPa Ethylene.

In the drybox, a glass insert was loaded with the isolated allyl initiator. The insert was cooled to -35°C in the drybox freezer, 5 mL of solvent (typically C₆D₆ or CDCl₃) was added to the cold insert, and the insert was cooled again. A Lewis acid cocatalyst [typically BPh₃ or B(C₆F₅)₃] was often added to the cold solution, and the insert was then capped and

sealed. Outside of the drybox, the cold tube was placed under ethylene (typically 6.9 MPa) and allowed to warm to rt as it was shaken mechanically for approximately 18 h. An aliquot of the solution was
5 used to acquire a ^1H NMR spectrum. The remaining portion was added to ~20 mL of MeOH in order to precipitate the polymer. The polyethylene was isolated and dried under vacuum.

10 General Procedure for the Screening of Ethylene Polymerizations by Nickel Allyl Initiators at 28-35 kPa Ethylene with Polymethylaluminoxane (PMAO) Cocatalyst.

In the drybox, the nickel complex was placed in a Schlenk flask and dissolved in ~ 20 mL of toluene. The flask was sealed, removed from the drybox and attached
15 to an ethylene line where it was purged with first nitrogen and then ethylene. After purging with ethylene, PMAO was quickly added to the reaction mixture and the flask was placed under 28-35 kPa of ethylene. After being stirred overnight, the reaction
20 mixture was quenched with ~15 mL of a solution of concentrated HCl in methanol (10:90 volume percent solution). The polymer was collected on a frit, washed with methanol and then acetone and then dried in vacuo overnight.

25 General Procedure for the Screening of Propylene Polymerization by Nickel Allyl Initiators at 48 kPa Propylene with Polymethylaluminoxane (PMAO) Cocatalyst.

In the drybox, the nickel complex was placed in a Schlenk flask and dissolved in ~ 10 mL of toluene. The
30 flask was sealed, removed from the drybox and attached to an ethylene line where it was purged with first nitrogen and then propylene. After purging with propylene, PMAO was quickly added to the reaction mixture and the flask was placed under ~ 48 kPa of
35 propylene. After being stirred overnight, the reaction mixture was quenched with ~ 10 mL of a solution of concentrated HCl in methanol (10:90 volume percent solution). The polymer was collected on a frit, washed

with methanol and then acetone and then dried in vacuo overnight.

General Procedure for the Screening of Propylene
Polymerization by Nickel Allyl Initiators at 48 kPa

5 Propylene with B(C₆F₅)₃ Cocatalyst.

In the drybox, the nickel complex was placed in a Schlenk flask and dissolved in ~10 mL of CH₂Cl₂. Two equiv of B(C₆F₅)₃ were dissolved in a minimal amount of CH₂Cl₂ and the solution was transferred to the Schlenk
10 flask. The flask was sealed, removed from the drybox and attached to an ethylene line where it was purged with first nitrogen and then propylene. The flask was placed under ~48 kPa of propylene and the reaction mixture was stirred overnight and then was quenched
15 with ~10 mL of a solution of concentrated HCl in methanol (10:90 volume percent solution). The polymer was collected on a frit, washed with methanol and then acetone and then dried in vacuo overnight

20 General Procedure for the Screening of Propylene
Polymerization by Nickel Allyl Initiators at 600 kPa

Propylene with B(C₆F₅)₃ Cocatalyst.

In the drybox, the nickel complex was placed in a vessel and dissolved in ~20 mL of CH₂Cl₂. Two equiv of B(C₆F₅)₃ were dissolved in 10 mL of CH₂Cl₂ and placed
25 in a separate vessel. Both vessels were sealed and removed from the drybox. The solution of the nickel complex was transferred to a 100 mL Parr reactor under vacuum and the solution of B(C₆F₅)₃ was transferred to the addition port of the same reactor. The B(C₆F₅)₃
30 solution was forced into the reactor ~600 kPa of propylene. The reactor pressure was maintained at 600 kPa and the reaction mixture was stirred for 3 h. Next, the reaction mixture was quenched with ~ 10 mL of a solution of concentrated HCl in methanol (10:90
35 volume percent solution). If polymer was present, it was collected on a frit, washed with methanol and then acetone and then dried in vacuo overnight. Oligomers were characterized by GC analysis.

Table 1

Reaction Conditions Used in Ethylene and Propylene Polymerizations^a

A	5 mL C ₆ D ₆ , rt, 18 h, 6.9 MPa E, 2 equiv BPh ₃
B	5 mL CDCl ₃ , 80 °C, 18 h, 6.9 MPa E, 1 equiv B(C ₆ F ₅) ₃
C	5 mL C ₆ D ₆ , 80 °C, 18 h, 6.9 MPa E, 2 equiv BPh ₃
D	5 mL C ₆ D ₆ , rt, 18 h, 6.9 MPa E, 1 equiv B(C ₆ F ₅) ₃
E	5 mL C ₆ D ₆ , 80 °C, 18 h, 6.9 MPa E, 2 equiv B[3,5-C ₆ H ₃ -(CF ₃) ₂] ₃
F	5 mL CDCl ₃ , rt, 18 h, 6.9 MPa E, 2 equiv B[3,5-C ₆ H ₃ -(CF ₃) ₂] ₃
G	5 mL CDCl ₃ , rt, 18 h, 6.9 MPa E, 2 equiv B(C ₆ F ₅) ₃
H	5 mL CDCl ₃ , 80 °C, 18 h, 6.9 MPa E, 2 equiv B(C ₆ F ₅) ₃
I	20 mL toluene, rt, overnight, 28-35 kPa E, excess PMAO
J	10 mL toluene, rt, overnight, 48 kPa P, excess PMAO
K	10 mL CH ₂ Cl ₂ , rt, overnight, 48 kPa P, 2 equiv B(C ₆ F ₅) ₃
L	30 mL CH ₂ Cl ₂ , rt, 3 h, 600 kPa P, 2 equiv B(C ₆ F ₅) ₃

^aAbbreviations. E: Ethylene; P: Propylene; PMAO: Polymethylaluminoxane.

5

Table 2

Polymerization of Ethylene by Compounds 1-20 at 6.9 MPa Ethylene

Conditions A (5 mL C ₆ D ₆ , rt, 18 h, 2 equiv BPh ₃)				Conditions B (5 mL CDCl ₃ , 80 °C, 18 h, 1 equiv B(C ₆ F ₅) ₃)			
Ex.	Cmpd ^b	PE (g) ^c	TO ^d	Ex.	Cmpd ^b	PE (g) ^c	TO ^d
41	1a	0.43 ^e	260	61	1a	0.40 ^e	240
42	2a	a	a	62	2a	1.2	730
43	3a	4.1	2400	63	3a	a	a
44	4a	12.7	7500	64	4a	a	a
45	5a	5.1	3000	65	5a	a	a
46	6a	1.3 ^g	590	66	6a	1.09	650
47	7a	a	a	67	7a	0.14	81
48	8a	0.29	170	68	8a	2.65	1600
49	9a	0.70	410	69	9a	2.5	1500
50	10a	0.33	200	70	10a	a	a
51	11a	a	a	71	11a	0.24	140
52	12a	0.15	87	72	12a	0.16	95
53	13a	a	a	73	13a	0.66	390
54	14a	1.1	640	74	14a	1.2	730
55	15a	0.14	80	75	15a	0.21	120
56	16a	a	a	76	16a	2.3	1400
57	17a	0.52	310	77	17a	1.33	780
58	18a	0.35	590	78	18a	a	a
59	19a	0.53	310	79	19a	a	a
60	20a	0.14	81	80	20a	a	a

^aLess than 0.1 g of polyethylene was isolated. ^b0.06 mmol ^cPE: Polyethylene. ^dTO: number of turnovers per metal center = (moles ethylene consumed, as determined by the weight of the isolated polymer or oligomers) divided by (moles catalyst). ^e1 equiv of B(C₆F₅)₃ was used (Conditions D in Table 1). ^f5 mL C₆D₆ and 2 equiv BPh₃ were used (Conditions C in Table 1). ^g1 equiv BPh₃ was used.

10

Table 3
Characterization of Polyethylenes Produced by Complexes 1-20

Ex.	Cmpd (Conds)	Mw	Mn	PDI	T _m (°C)	NMR Analysis (Branching per 1000 CH ₂)
81	1a(C)	703000	6640	106		¹ H NMR: 16.5 Total Methyls
82	1a(D)	1320000	16100	81.6		¹³ C NMR: 74.0 Total Methyls; Branch Lengths: Methyl (38.7), Ethyl (11.0), Propyl (5.3), Butyl (5.9), Amyl (3), \geq Hex ^b (4.5), \geq Am ^b (11.3), \geq Bu ^b (21.4)
83	1a(E)	259000	6550	39.5	68 ^c 110	¹ H NMR: 54.9 Total Methyls
84	2a(B)	21100	2840	7.44	101	¹³ C NMR: 58.4 Total Methyls; Branch Lengths: Methyl (37.5), Ethyl (4.3), Propyl (2.3), Butyl (2), Amyl (2.4), \geq Hex ^b (9.9), \geq Am ^b (11.8), \geq Bu ^b (14.4)
85	3a(A)				120	¹³ C NMR: 27.9 Total Methyls; Branch Lengths: Methyl (21.7), Ethyl (2.4), Propyl (0.5), Butyl (0.7), Amyl (0.4), \geq Hex ^b (2.6), \geq Am ^b (2.5), \geq Bu ^b (3.3)
86	4a(A)					¹³ C NMR: 52.0 Total Methyls; Branch Lengths: Methyl (38.0), Ethyl (2.3), Propyl (2.5), Butyl (2.9), Amyl (2.5), \geq Hex ^b (3.0), \geq Am ^b (6.0), \geq Bu ^b (5.4)
87	5a(A)	88600	11100	7.95		¹³ C NMR: 94.7 Total Methyls; Branch Lengths: Methyl (66.7), Ethyl (12.5), Propyl (0.5), Butyl (3.0), Amyl (3.3), \geq Hex ^b (6.0), \geq Am ^b (10.0), \geq Bu ^b (9.8)
88	6a(A)	d	d	d		¹³ C NMR: 6.4 Total Methyls; Branch Lengths: Methyl (5.5)
89	6a(C-1)	19,600	7580	2.58		¹ H NMR: 30.2 Total Methyls
90	6a(C-2)	12,700	3680	3.45	108	¹³ C NMR: 38.8 Total Methyls; Branch Lengths: Methyl (23.1), Ethyl (4.0), Propyl (1.8), Butyl (0), Amyl (0.9), \geq Hex ^b (2.6), \geq Am ^b (5.7), \geq Bu ^b (9.6)

Table 3 (cont'd)
 Characterization of Polyethylenes Produced by Complexes 1-20

Ex.	Cmpd (Conds)	Mw	Mn	PDI	T _m (°C)	NMR Analysis (Branching per 1000 CH ₂)
91	6a(E)	10800	2910	3.71	101	¹ H NMR: 42.8 Total Methyls
92	6a(F)	128000	9040	14.1	131	¹ H NMR: 3.1 Total Methyls
93	7a(B)	22300	6170	3.62	127	
94	8a(A)	d	d	d	130	
95	8a(B)	8770	1600	5.47	80	¹³ C NMR: 68.0 Total Methyls; Branch Lengths: Methyl (41.1), Ethyl (8.8), Propyl (0.5), Butyl (2.6), Amyl (5.6), ≥Hex _b (9.9), ≥Am _b (14.7), ≥Bu _b (16.8)
96	9a(A)	d	d	d	130	¹³ C NMR: 18.7 Total Methyls; Branch Lengths: Methyl (16.0)
97	9a(B)	60800	590	103	124	¹³ C NMR: 119.0 Total Methyls; Branch Lengths: Methyl (66.0), Ethyl (22.5), Propyl (5.0), Butyl (8.7), Amyl (7.5), ≥Hex _b (15.5), ≥Am _b (23.9), ≥Bu _b (28.4)
98	10a(A)	25600	6180	4.14	128	¹ H NMR: 11.4 Total Methyls
99	11a(B)	77500	3090	25.1	119	
100	13a(B)	15500	3580	4.33	97	
101	14a(A)	d	d	d	129	
102	14a(B)	68900	3070	22.4	78	
103	15a(B)	23800	7560	3.15	129	¹ H NMR: 57.8 Total Methyls

Table 3 (cont'd)
Characterization of Polyethylenes Produced by Complexes 1-20

Ex.	Cmpd (Conds)	Mw	Mn	PDI	T _m (°C)	NMR Analysis (Branching per 1000 CH ₂)
104	16a(B)	69400	885	78.4	117	¹³ C NMR: 48 Total Methyls; Branch Lengths: Methyl (24.8), Ethyl (5.9), Propyl (1), Butyl (2.6), Amyl (6), ≥Hex ^b (11.8), ≥Am ^b (14.2), ≥Bu ^b (16.3)
105	17a(A)	d	d	d	132	¹ H NMR: 19.5 Total Methyls
106	17a(B)	325000	2080	156	128	¹³ C NMR: 25.2 Total Methyls; Branch Lengths: Methyl (17.9), Ethyl (4.3), Propyl (1.3), Butyl (1.9), Amyl (2.5), ≥Hex ^b (3.7), ≥Am ^b (4.4), ≥Bu ^b (0.8)
107	18a(A)	24800	8730	2.84		¹ H NMR: 22.8 Total Methyls
108	19a(A)	90600	1630	55.7	123	¹³ C NMR: 47.4 Total Methyls; Branch Lengths: Methyl (23.7), Ethyl (5.6), Propyl (1.4), Butyl (2.1), Amyl (6.6), ≥Hex ^b (12.7), ≥Am ^b (14.8), ≥Bu ^b (16.7)

^aReaction conditions are given in Table 1. ^bIncludes ends of chains. ^cHeterogeneous conditions in the glass insert during mixing can account for the observation of two T_m's. ^dGPC could not be performed due to the insolubility of the sample.

Table 4

Polyethylene Yields: Demonstration of Effects of Reaction Conditions and Reproducibility of Yields Using Rapid Screening Techniques with Compound 6

5

Ex.	Reaction Conditions ^b	Polyethylene Yield (g)				
		Run 1	Run 2	Run 3	Run 4	Run 5
109 - 113	A: 5 mL C ₆ D ₆ , rt, 18 h, 6.9 MPa E, 2 equiv BPh ₃	a	0.10	0.10	a	1.3 ^c
114 - 115	B: 5 mL CDCl ₃ , 80 °C, 18 h, 6.9 MPa E, 1 equiv B(C ₆ F ₅) ₃	0.10	0.28			
116 - 118	C: 5 mL C ₆ D ₆ , 80 °C, 18 h, 6.9 MPa E, 2 equiv BPh ₃	9.50	9.55	0.49 ^d		
119 - 121	G: 5 mL CDCl ₃ , rt, 18 h, 6.9 MPa E, 2 equiv B(C ₆ F ₅) ₃	a	0.65	7.78		
122 - 123	H: 5 mL CDCl ₃ , 80 °C, 18 h, 6.9 MPa E, 2 equiv B(C ₆ F ₅) ₃	1.09	1.09			

^aLess than 0.1 g of polyethylene was isolated. ^bE: Ethylene; H⁺(CO₂Me)CH₂ initiator was used unless otherwise noted. ^c1 equiv of BPh₃ was used. ^dH₂CCHCHCl allyl initiator was used.

10

Table 5

Polymerization of Ethylene and Propylene at Low Pressures

Ex.	Cmpd (mmol)	Conds ^a	Gas (kPa) ^b	Polymer (g)	TO ^c	T _m (°C)
124	1a (0.11)	I	E (27-35)	2.91	970	d
125	6a (0.12)	I	E (27-35)	0.42	128	125
126	15a (0.15)	I	E (27-35)	0.11	27	121 ^e
127	20a (0.11)	I	E (27-35)	0.27	88	f
128	1a (0.06)	J	P (48)	1.84	730	g
129	1a (0.06)	K	P (48)	0.21	81	h
130	6a (0.06)	L	P (600)	11.2 ⁱ	4400 ⁱ	j

^aReaction conditions are defined in Table 1. ^bE: Ethylene. P: Propylene. ^cTO: number of turnovers per catalyst center = (moles monomer consumed, as determined by the weight of the isolated polymer or oligomers) divided by (moles catalyst). ^dClear, rubbery amorphous PE. ^eWhite, rubbery PE. ^fWhite, crystalline PE. ^gClear rubbery PP. ^hClear sticky PP. ⁱ14 mL of liquid oligomers were isolated. A density of 0.8 g/mL was assumed. ^jGC analysis indicates that pentamers, hexamers and heptamers predominate.

15

Examples 131-136Styrene and Norbornene Homo- and Copolymerizations

In the subsequent examples describing polymerizations of styrene and norbornene, all manipulations were carried out in a nitrogen-purged drybox. Anhydrous solvents were used. The styrene (99+%, Aldrich, inhibited with 4-tert-butylcatechol) was degassed, filtered through basic alumina and inhibited with phenothiazine (98+%, Aldrich, 50 ppm) before use. The norbornene was purified by vacuum sublimation. Tacticities of polystyrenes were measured according to the following reference: T Kawamura et al., *Macromol. Rapid Commun.* **1994**, *15*, 479-486.

General Procedure for Styrene Polymerizations.

The nickel complex (0.03 mmol) was slurried in dry toluene (6 mL) and styrene (1.3 mL, 1.18 g, 11.3 mmol) was added. Two equiv of $B(C_6F_5)_3$ were then added with vigorous stirring. The resulting mixture was shaken at rt in the dark for 16 h after which time the sample was removed from the drybox and MeOH was added to precipitate the polymer. The solid polymer was isolated, redissolved in $CHCl_3$ and reprecipitated with MeOH to remove catalyst impurities. The product was then collected on a frit, washed with MeOH and finally with a MeOH/acetone/Irganox® 1010 solution.

General Procedure for Norbornene Polymerizations.

The nickel complex (0.03 mmol) was slurried in dry toluene (6 mL) and norbornene (1.6 g, 17.0 mmol) was added. Two equiv of $B(C_6F_5)_3$ were then added with vigorous stirring. The resulting mixture was shaken at rt. After 16 h, the sample was removed from the drybox and MeOH was added to precipitate the polymer. The solid polymer was isolated. The polymer was redissolved or swollen with solvent in order to remove catalyst impurities and then reprecipitated with MeOH. The product was then collected on a frit, washed with MeOH and finally with an acetone/2% Irganox® 1010 solution.

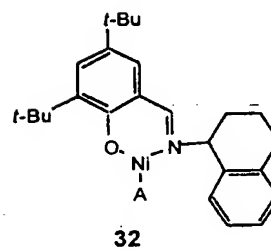
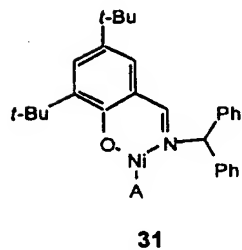
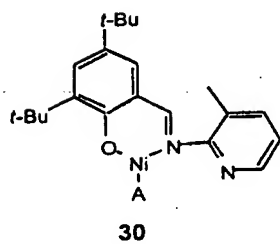
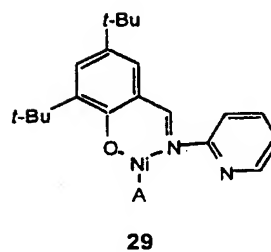
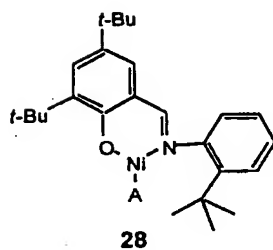
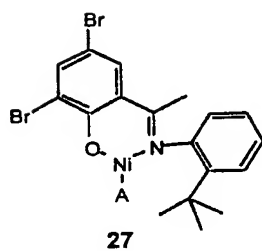
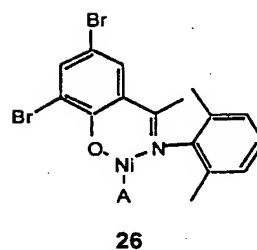
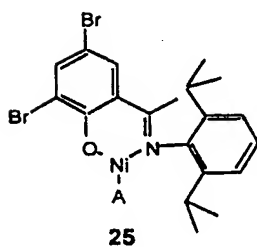
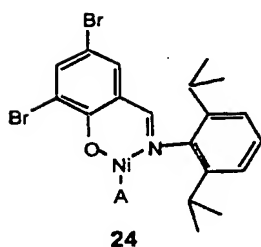
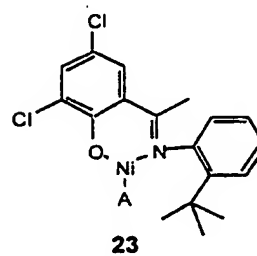
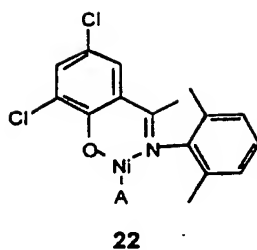
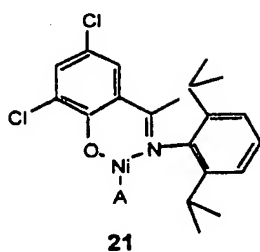
General Procedure for Styrene/Norbornene

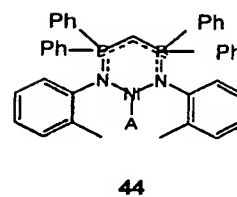
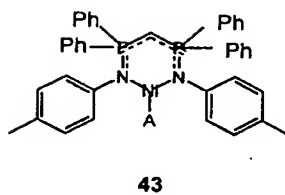
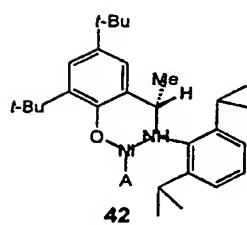
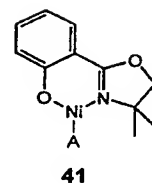
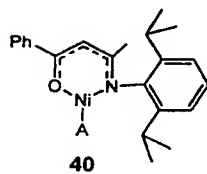
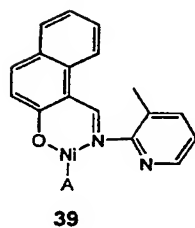
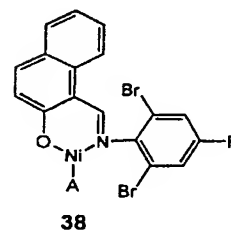
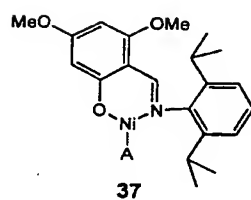
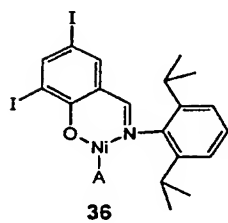
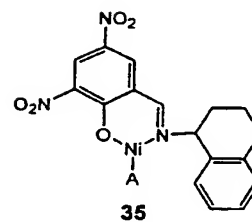
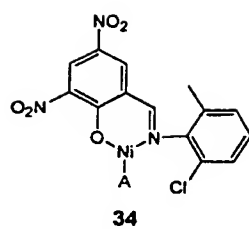
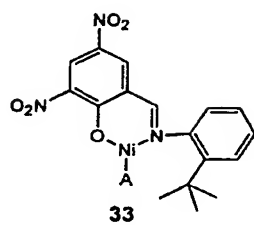
Copolymerizations. The nickel complex (0.03 mmol) was slurried in dry toluene (5 mL) and a mixture of norbornene (1.17 g, 12.4 mmol) and styrene (1.4 mL, 1.27 g, 12.2 mmol) in toluene (3 mL) was added. Two equiv of B(C₆F₅)₃ were then added with vigorous stirring. The resulting mixture was shaken at rt in the dark for 5 h. The sample was then removed from the drybox and MeOH was added to precipitate the polymer. The isolated polymer was dissolved (CHCl₃) and reprecipitated (MeOH) to remove the catalyst residue. The product was stirred overnight in acetone to remove polystyrene and then filtered, washed with MeOH and finally with an acetone/2% Irganox® 1010 solution.

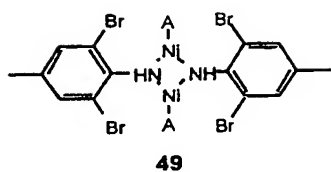
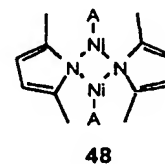
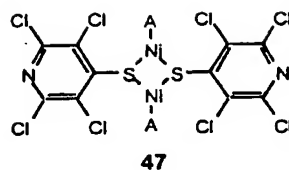
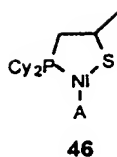
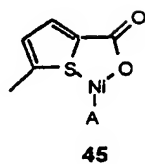
Table 6
Styrene (S) and Norbornene (N) Homo- and Copolymerizations

Ex.	Cmpd	Monomers	Yield (%)	TO ^a		Mn ^b	PDI	% S
				S	N			
131	3a	S	79	300	-	2140	1.9	100 ^c
132	6a	S	54	200	-	3390	1.8	100 ^c
133	3a	N	>95	-	570	<i>d</i>	<i>d</i>	\bar{N}
134	6a	N	>95	-	570	<i>d</i>	<i>d</i>	\bar{N}
135	3a	S, N	21	13	170	9580	2.5	8
136	6a	S, N	7	4	56	15500	2.0	7

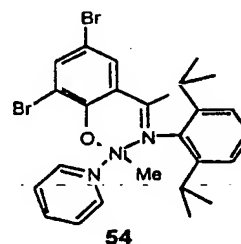
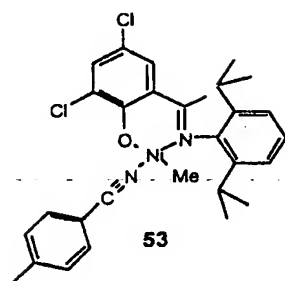
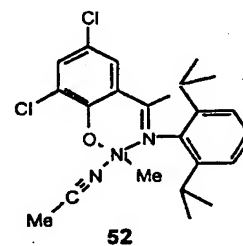
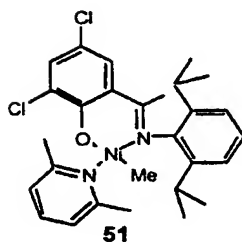
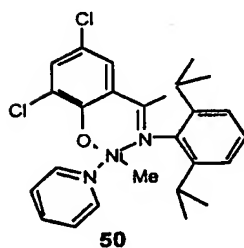
^aNumber of turnovers: TO = (moles monomer consumed, as determined by the weight of the isolated polymer) divided by (moles catalyst). ^bM_n (GPC, TCB 120°C, polystyrene standards). ^c¹³C NMR spectroscopy (CDCl₃) indicates enrichment in meso diad units relative to atactic polystyrene. ^dWithin 30 min the reaction mixture completely solidified and attempts to redissolve the polymer were unsuccessful. The insolubility of the polymer product indicates that an addition polymer of norbornene was formed.







A (Allyl)



Compounds 21-54. The syntheses and
 5 characterization of compounds 21-60 and their ligand
 precursors are reported in Examples 467 to 498. These
 compounds are used in the following Examples.

Examples 137 - 187Styrene Homopolymerizations and Styrene/Norbornene
Copolymerizations

In the subsequent examples describing
5 polymerizations of styrene and norbornene, all
manipulations were carried out in a nitrogen-purged
drybox. Anhydrous solvents were used. The styrene
(99+%, Aldrich, inhibited with 4-*tert*-butylcatechol)
was degassed, filtered through basic alumina and
10 inhibited with phenothiazine (98+%, Aldrich, 50 ppm)
before use. The norbornene was purified by vacuum
sublimation. Tacticities of polystyrenes were measured
according to the following reference: T Kawamura et
al., *Macromol. Rapid Commun.* **1994**, 15, 479-486.

15 General Procedure for Styrene Polymerizations
(Table 7). The nickel complex (0.03 mmol) was slurried
in dry toluene (6 mL) and styrene (1.6 mL, 14 mmol) was
added. Two equiv of B(C₆F₅)₃ were then added with
vigorous stirring. The resulting mixture was shaken at
20 rt in the dark for 5 h after which time the sample was
removed from the drybox and MeOH was added to
precipitate the polymer. The solid polymer was
isolated, redissolved in CHCl₃ and reprecipitated with
MeOH to remove catalyst impurities. The product was
25 then collected on a frit, washed with MeOH and finally
with a MeOH/ acetone/Irganox® 1010 solution. The
polymer was then dried under vacuum.

General Procedure for Styrene/Norbornene
Copolymerizations (Table 8). The nickel complex (0.03
30 mmol) was slurried in dry toluene (5 mL) and a mixture
of norbornene (1.41 g, 15 mmol) and styrene (1.7 mL, 15
mmol) in toluene (3 mL) was added. Two equiv of
B(C₆F₅)₃ were then added with vigorous stirring. The
resulting mixture was shaken at rt in the dark
35 overnight. The sample was then removed from the drybox
and added to MeOH to precipitate the polymer. The
product was stirred overnight in acetone to remove
polystyrene and then filtered, washed with MeOH and

finally with an acetone/2% Irganox 1010 solution. The polymer was then dried under vacuum.

5

Table 7
Styrene Homopolymerizations

Ex.	Cmpd	Yield (%)	TO ^a	M _n ^b	PDI	Tacticity
137	1a	e	e			
138	2a	e	e			
139	4a	41	192	16,000	2.0	enriched in meso diads ^c
140	5a	61	282	14,900	2.1	enriched in meso diads ^c
141	8a	15	70	2,390	3.8	enriched in meso diads ^c
142	9a	0.7	3.2			
143	14a	36	170	2,010	5.4	enriched in meso diads ^c
144	15a	31	144	1,350	2.4	enriched in meso diads ^c
145	16a	e	e			
146	17a	9	42	5,800	2.2	enriched in meso diads ^c
147	21a	72	336	770	2.7	enriched in meso diads ^c
148	22a	66	304	760	2.7	enriched in meso diads ^c
149	24a	73	340	1,010	2.9	enriched in meso diads ^c
150	28a	48	221	730	2.9	enriched in meso diads ^c
151	31a	57	265	2,230	1.8	enriched in meso diads ^c
152	32a	78	362	14,900	2.1	enriched in meso diads ^c
153	33a	26	122	830	2.3	enriched in meso diads ^c
154	35a	6	29	18,800	5.1	highly isotactic
155	35a ^d	29	134	4,150	6.8	highly isotactic
156	39a	4.1	19			enriched in r diads ^c
157	40a	58	269	785	3.5	enriched in meso diads ^c
158	42a	57	265	800	2.8	enriched in meso diads ^c
159	46a	6	29	1,980	1.4	highly isotactic
160	47b	15	70	1,200	6.3	enriched in meso diads ^c
161	48a	48	221	1,660	8.3	enriched in meso diads ^c
162	49a	9	42	12,200	2.6	enriched in meso diads ^c

^aNumber of turnovers: TO = (moles styrene consumed, as determined by the weight of the isolated polymer) divided by (moles catalyst). ^bM_n (GPC, TCB, 120°C, polystyrene standards). ^cAccording to ¹³C NMR spectroscopy (CDCl₃) and relative to atactic polystyrene. ^d60 °C. ^eNo polymer was isolated.

10

Table 8
Styrene (S) and Norbornene (N) Copolymerizations

Ex.	Cmpd	Yield (%)	TO ^a		M _n ^b	PDI	% S
			S	N			
163	1a	4.7	c	47	5,330	5	<5
164	2a	40	c	400	11,000	3.9	<5
165	4a	43	44	390	7,630	3.3	11
166	5a	27	15	251	5,430	2.3	6.7
167	8a	14	c	141	14,300	2.7	<5
168	9a	8.5	c	84	8,100	2.3	<5
169	14a	32	17	303	7,290	3.4	5.8
170	15a	36	29	329	7,140	3.0	9
171	16a	8.8	c	92	6,920	2.6	<5
172	17a	7.8	c	78	7,060	2.3	<5
173	21a	44	41	400	2,730	3.8	10.2
174	22a	47	45	425	3,340	3.3	10.5
175	24a	15	5	142	5,800	3.0	3.7
176	28a	45	47	415	2,680	3.9	11.2
177	31a	30	c	300	4,700	2.4	<5
178	32a	26	19	236	5,670	2.2	7.5
179	33a	31	13	300	5,940	2.6	4.5
180	35a	7.4	c	74	20,500	2.4	<5
181	39a	3.0	c	262	5,054	2.9	<5
182	40a	18	5	172	5,960	2.9	3.0
183	42a	43	31	398	2,470	4.4	8.7
184	46a	38	c	379	14,800	2.8	<5
185	47b	17	c	170	4,570	6.2	<5
186	48a	8	c	78	17,600	2.5	<5
187	49a	15	c	145	7,500	2.3	<5

5 ^aNumber of turnovers: TO = (moles monomer consumed, as determined by the weight of the isolated polymer) divided by (moles catalyst). ^bM_n (GPC, TCB, 120°C, polystyrene standards).

^cLow styrene incorporation (<5%) precluded calculation of the styrene turnover numbers.

Examples 188 - 194

Norbornene Homopolymerizations and Norbornene/Functionalized-Norbornene Copolymerizations

Example 188Norbornene Homopolymerization Catalyzed by 52/B(C₆F₅)₃.

In a 20 mL scintillation vial under nitrogen, compound **52** (0.010 g, 0.021 mmol) and norbornene (1.00 g, 10.62 mmol) were dissolved in 5 mL of toluene to give an orange solution. To this was added B(C₆F₅)₃ (0.011 g, 0.022 mmol). After 30 min at ambient temperature, more B(C₆F₅)₃ was added to the reaction mixture (0.110 g, 0.214 mmol). An extremely viscous, yellow suspension formed very rapidly and within minutes the reaction mixture could no longer be stirred. Twenty-three h after the initial addition of B(C₆F₅)₃, the reaction mixture was quenched by addition of methanol under air. Further workup afforded 0.93 g of polymer. ¹H NMR (1,1,2,2-tetrachloroethane-d₂, 120°C) indicated that the polymer was the addition polymer of norbornene formed without double bond ring-opening.

Example 189

20 Copolymerization of Norbornene with the Dimethyl Ester of endo-5-Norbornene-2,3-Dicarboxylic Acid Catalyzed by 21a/B(C₆F₅)₃ (Copolymer: ~30 Mole % Dimethyl Ester)

In a 20 mL scintillation vial under nitrogen, compound **21a** (0.015 g, 0.029 mmol), norbornene (0.500 g, 5.31 mmol), and the dimethyl ester of 5-norbornene-2,3-dicarboxylic acid (1.00 g, 4.76 mmol) were dissolved in 10 mL of toluene. To this solution was added solid B(C₆F₅)₃ (0.029 g, 0.058 mmol). The resulting solution was stirred initially at ambient temperature by means of a magnetic stirbar; however, after several minutes the reaction mixture consisted of a viscous, solvent-swollen polymer that could not be stirred. Twenty-seven h after the addition of B(C₆F₅)₃, the reaction mixture was quenched by addition of the solvent-swollen reaction mixture to methanol under air. The precipitated polymer was filtered off, washed with methanol, and dried to afford 0.810 g of addition copolymer. ¹H NMR (CD₂Cl₂, 25 °C) indicated the

following composition: norbornene (74 mole %),
dimethyl ester (26 mole %). Quantitative ^{13}C NMR
(trichlorobenzene- d_3 , 100 °C) indicated the following
composition: norbornene (70.8 mole %), dimethyl ester
5 (29.2 mole %).

Example 190

Copolymerization of Norbornene with the Dimethyl Ester
of endo-5-Norbornene-2,3-Dicarboxylic Acid Catalyzed by
21a/B(C₆F₅)₃ (Copolymer: ~22 Mole % Dimethyl Ester)

10 A reaction identical to that above in Example 189,
but run in CH₂Cl₂ instead of toluene gave the following
results: Yield = 0.63 g. ^1H NMR (CDCl₃, 25 °C)
indicated the following composition: norbornene (81%),
dimethyl ester (19%). Quantitative ^{13}C NMR
15 (trichlorobenzene- d_3 , 100 °C): norbornene (78.11 mole
%), dimethyl ester (21.89 mole %).

Example 191

Copolymerization of Norbornene with the Dimethyl Ester
of endo-5-Norbornene-2,3-Dicarboxylic Acid Catalyzed by
20 21a/B(C₆F₅)₃ (Copolymer: ~11 mole % Dimethyl Ester)

In a 20 mL scintillation vial under nitrogen,
compound 21a (0.015 g, 0.029 mmol), norbornene (3.00 g,
31.86 mmol), the dimethyl ester of 5-norbornene-2,3-
dicarboxylic acid (1.00 g, 4.76 mmol), and B(C₆F₅)₃
25 (0.029 g, 0.058 mmol) were dissolved in 10 mL of
toluene. The resulting yellow solution was stirred
initially at ambient temperature by means of a magnetic
stirbar; however, within 15 minutes an extremely rapid,
highly exothermic reaction ensued. The reaction
30 mixture setup and could not be stirred after this
point. Three h after the addition of B(C₆F₅)₃, the
reaction mixture was quenched by addition of the
solvent-swollen reaction mixture to methanol under air.
Further workup afforded 3.75 g of addition copolymer.
35 ^1H NMR (CDCl₃, 25 °C) indicated the following
composition: norbornene (90 mole %), dimethyl ester
(10 mole %). Quantitative ^{13}C NMR (trichlorobenzene- d_3 ,

100 °C) indicated the following composition:
norbornene (89.05 mole%), dimethyl ester (10.95 mole%).

Example 192

Copolymerization of Norbornene with the Dimethyl Ester
5 of endo-5-Norbornene-2,3-Dicarboxylic Acid Catalyzed by
21a / B(C₆F₅)₃ (Copolymer: ~6 mole % Dimethyl Ester)

A reaction identical to that above in Example 191,
but run in CH₂Cl₂ instead of toluene gave the following
results: Yield = 3.12 g. ¹H NMR (CDCl₃, 25 °C)
10 indicated the following composition: norbornene (96
mole %), dimethyl ester (4 mole %). Quantitative ¹³C
NMR (trichlorobenzene-d₃, 100 °C): norbornene (94.19
mole %), dimethyl ester (5.81 mole %).

Example 193

15 Copolymerization of Norbornene with the t-Bu Ester of
5-Norbornene-2-Carboxylic Acid Catalyzed by 50/B(C₆F₅)₃
(Copolymer: ~30 mole % t-Bu Ester)

In a 20 mL scintillation vial under nitrogen,
compound 50 (0.010 g, 0.020 mmol), norbornene (0.500 g,
20 5.31 mmol), and the t-Bu ester of 5-norbornene-2-
carboxylic acid (1.00 g, 5.15 mmol) were dissolved in 5
mL toluene. To this solution was added B(C₆F₅)₃ (0.102
g, 0.200 mmol). The resulting yellow solution was
stirred at ambient temperature for 16 h. The reaction
25 mixture was quenched and the copolymer precipitated by
addition of methanol under air. Further workup
afforded 0.664 g of addition copolymer. Quantitative
¹³C NMR (trichlorobenzene-d₃, 100 °C) indicated the
following composition: norbornene (70.4 mole %), t-Bu
30 ester (29.6 mole %).

Example 194

Copolymerization of Norbornene with the Dimethyl Ester
of endo-5-Norbornene-2,3-Dicarboxylic Acid Catalyzed by
35 52/B(C₆F₅)₃ (Copolymer: ~32 mole % Dimethyl Ester)

In a 20 mL scintillation vial under nitrogen,
compound 52 (0.010 g, 0.021 mmol), norbornene (0.500 g,
5.31 mmol), and the dimethyl ester of 5-norbornene-2,3-
dicarboxylic acid (1.00 g, 4.76 mmol) were dissolved in

5 mL of toluene. To this solution was added a suspension of $B(C_6F_5)_3$ (0.029 g, 0.058 mmol) in 5 mL of toluene. The resulting orange solution was stirred initially at ambient temperature by means of a magnetic stirbar; however, after several minutes the reaction mixture consisted of a viscous, solvent-swollen polymer that could not be stirred. Twenty-two h after the addition of $B(C_6F_5)_3$, the reaction mixture was quenched by addition of the solvent-swollen reaction mixture to methanol under air. The precipitated polymer was filtered off, washed with methanol, and dried to afford 0.930 g of addition copolymer. 1H NMR ($CDCl_3$, 25 °C) indicated the following composition: norbornene (68 mole %), dimethyl ester (32 mole %).

Examples 195 - 366

Ethylene Polymerizations

General Procedure for Ethylene Polymerizations
of Table 9

Pressure Tube Loaded Outside of the Drybox Under a
Nitrogen Purge

(In the ethylene polymerization reactions of Tables 2, 3, and 4, the glass inserts were also loaded in the pressure reactor tube outside of the drybox under a nitrogen purge.) Procedure. In the drybox, a glass insert was loaded with the isolated allyl initiator (0.06 mmol). The insert was cooled to -35°C in the drybox freezer, 5 mL of C_6D_6 was added to the cold insert, and the insert was cooled again. A Lewis acid cocatalyst [typically BPh_3 or $B(C_6F_5)_3$] was added to the cold solution, and the insert was then capped and sealed. Outside of the drybox, the cold insert was placed under a nitrogen purge into the pressure tube. The pressure tube was sealed, placed under ethylene (6.9 MPa), and allowed to warm to rt as it was shaken mechanically for approximately 18 h. An aliquot of the solution was used to acquire a 1H NMR spectrum. The remaining portion was added to ~20 mL of MeOH in order

to precipitate the polymer. The polyethylene was isolated and dried under vacuum.

General Procedure for Ethylene Polymerizations of
Tables 10-14:

5 Pressure Tube Loaded and Sealed in the Drybox under a
 Nitrogen Atmosphere

 Procedure. In the drybox, a glass insert was loaded with the nickel compound. Often, a Lewis acid (typically BPh_3 or $\text{B}(\text{C}_6\text{F}_5)_3$) was also added to the glass
10 insert. Next, 5 mL of a solvent (typically 1,2,4-trichlorobenzene although *p*-xylene, cyclohexane, etc. were also used at times) was added to the glass insert and the insert was capped. The glass insert was then loaded in the pressure tube inside the drybox. The
15 pressure tube containing the glass insert was then sealed inside of the drybox, brought outside of the drybox, connected to the pressure reactor, placed under the desired ethylene pressure and shaken mechanically. After the stated reaction time, the ethylene pressure
20 was released and the glass insert was removed from the pressure tube. The polymer was precipitated by the addition of MeOH (~20 mL) and concentrated HCl (~1-3 mL). The polymer was then collected on a frit and rinsed with HCl, MeOH, and acetone. The polymer was
25 transferred to a pre-weighed vial and dried under vacuum overnight. The polymer yield and characterization were then obtained.

Table 9
Ethylene Polymerization (6.9 MPa, C₆D₆ (5 mL), 0.06 mmol Compd, 18 h)

Ex.	Compd	Temp (°C)	Lewis Acid ^a	PE(g)	PE(TO) ^b	M.W. ^c (MI, GPC, and/or ¹ H NMR)	Total Me ^d
195	21a	25	BPh ₃	3.34	2,000	MI: 79.5; M _n (¹ H): 3,670	36.9
196	21a	80	B(C ₆ F ₅) ₃	e	e		
197	22a	25	BPh ₃	4.41	2,600	MI > 200; M _n (¹ H): 1,890	85.5
198	22a	80	B(C ₆ F ₅) ₃	0.04	20		
199	24a	25	BPh ₃	15.3	9,100	MI < 0.01; M _n (¹ H): no olefins	4.5
200	24a	80	B(C ₆ F ₅) ₃	0.15	91		
201	28a	25	BPh ₃	0.30	180	M _n (¹ H): 18,900	67.1
202	28a	80	B(C ₆ F ₅) ₃	0.04	24		
203	31a	25	BPh ₃	f	f		
204	31a	80	B(C ₆ F ₅) ₃	f	f		
205	32a	25	BPh ₃	0.01 ^e	7 ^e		
206	32a	80	B(C ₆ F ₅) ₃	e	e		
207	33a	25	BPh ₃	0.21	120		
208	33a	80	B(C ₆ F ₅) ₃	1.60	950	MI: 79.5; M _n (¹ H): 1,390	51.2
209	35a	25	BPh ₃	0.19 ^e	110 ^e		
210	35a	80	B(C ₆ F ₅) ₃	0.11 ^e	68 ^e		
211	37a	25	BPh ₃	0.02 ^e	10 ^e		
212	38a	80	B(C ₆ F ₅) ₃	0.07 ^e	42 ^e		
213	39a	25	BPh ₃	f	f		
214	39a	80	B(C ₆ F ₅) ₃	2.11	1,300	MI: 105; M _n (¹ H): 5,200	21.5
215	40a	25	BPh ₃	0.08 ^e	50 ^e		
216	40a	80	B(C ₆ F ₅) ₃	e	e		
217	42a	25	BPh ₃	e	e		
218	42a	80	B(C ₆ F ₅) ₃	e	e		

^aTwo equiv. ^bTO: number of turnovers per metal center = (moles ethylene consumed, as determined by the weight of the isolated polymer or oligomers) divided by (moles catalyst).

^cM.W.: Molecular weight of the polymer or oligomers as determined by melt index (MI: g/10 min at 190 °C), GPC (molecular weights are reported versus polystyrene standards; conditions: Waters 150C, trichlorobenzene at 150 °C, Shodex columns at -806MS 4G 734/602005, RI detector), and/or ¹H NMR (olefin end group analysis).

^dTotal number of methyl groups per 1000 methylene groups as determined by ¹H NMR analysis. ^e¹H NMR: oligomers and/or (CH₂)_n peak observed.

^fPE was not obtained in isolable quantities.

Table 9 (Cont'd)
Ethylene Polymerization (6.9 MPa, C₆D₆ (5 mL), 0.06 mmol Cmpd, 18 h)

Ex.	Cmpd	Temp (°C)	Lewis Acid ^a	PE(g)	PE(TO) ^b	M.W. ^c (MI, GPC, and/or ¹ H NMR)	Total Me ^d
219	46a	25	BPh ₃	f	f		
220	46a	80	B(C ₆ F ₅) ₃	0.11	65		
221	47b	25	BPh ₃	0.12 ^e	71 ^e		
222	47b	80	B(C ₆ F ₅) ₃	e	e		
223	47b	25	BPh ₃	0.15	91		
224	47b	80	B(C ₆ F ₅) ₃	0.09	52		
225	48a	25	BPh ₃	0.07	43		
226	48a	80	B(C ₆ F ₅) ₃	0.22 ^e	132 ^e		
227	49a	25	BPh ₃	0.10	59		
228	49a	80	B(C ₆ F ₅) ₃	0.06 ^e	34 ^e		

^aTwo equiv. ^bTO: number of turnovers per metal center = (moles ethylene consumed, as determined by the weight of the isolated polymer or oligomers) divided by (moles catalyst).

5 ^cM.W.: Molecular weight of the polymer or oligomers as determined by melt index (MI: g/10 min at 190 °C), GPC (molecular weights are reported versus polystyrene standards; conditions: Waters 150C, trichlorobenzene at 150 °C, Shodex columns at -806MS 4G 734/602005, RI detector), and/or ¹H NMR (olefin end group analysis). ^dTotal number of methyl groups per 1000 methylene groups as determined by ¹H NMR analysis. ^e¹H NMR: oligomers and/or (CH₂)_n peak observed.

10 ^fPE was not obtained in isolable quantities. ^gThe general procedure for the screening of ethylene polymerizations by nickel allyl initiators at 6.9 MPa ethylene (*see above*) was followed.

Table 10
Ethylene Polymerizations at 6.9 MPa: Pressure Tube Loaded in the Drybox under N₂ Atmosphere
(Trichlorobenzene (5 mL), 18 h)

Ex.	Cmpd ^f	Temp (°C)	Lewis Acid ^a	PE(g)	PE(TO) ^b	M.W. ^c (MI, GPC, and/or ¹ H NMR)	Total Me ^d
229	3a	25	BPh ₃	8.31	12,900	MI: 5.5; M _n (¹ H): 18,100	36.9
230	3a ^g	25	BPh ₃	1.54	3,660	MI: 40; M _n (¹ H): no olefins	20.0
231	3a ^g	25	B(C ₆ F ₅) ₃	0.701	1,460	MI: 22.9; M _n (¹ H): 99,900	22.9
232	3a	80	BPh ₃	4.29	6,640	MI > 200; M _n (¹ H): 4,770	56.2
233	3a	80	B(C ₆ F ₅) ₃	0.203	359	M _n (¹ H): 2,500	47.7
234	4a	25	BPh ₃	2.44	4,630	MI: 126; M _n (¹ H): 10,300	43.5
235	4a	80	BPh ₃	2.19	3,640	MI > 200; M _n (¹ H): 2,270	75.5
236	4a	80	B(C ₆ F ₅) ₃	0.096	190	M _n (¹ H): 3,260	29.3
237	5a	25	BPh ₃	4.98	8,630	M _w (GPC): 14,100; PDI: 6.7	93.2
238	5a	80	BPh ₃	2.72	4,710	M _w (GPC): 2,850; PDI: 3.7	137.3
239	6a	25	BPh ₃	4.44	7,730	MI: 0.85	
240	6a ⁱ	25	B(C ₆ F ₅) ₃	6.18	5,490	MI: 1.2; M _n (¹ H): 9,620	28.5
241	6a ^g	80	BPh ₃	4.13	10,500	MI: 21; M _n (¹ H): 12,200	28.4
242	6a ^h	80	BPh ₃	13.1	7,800	MI > 200; M _n (¹ H): 3,030	79.0
243	6a	80	B(C ₆ F ₅) ₃	3.31	5,990	MI: 81; M _n (¹ H): 5,920	34.7
244	6a ^g	80	B(C ₆ F ₅) ₃	3.14	7,300	MI: 45	
245	6a ^h	80	B(C ₆ F ₅) ₃	8.92	5,300	MI > 200; M _n (¹ H): 1,420	89.1
246	7a	25	BPh ₃	0.93	1,350	MI < 0.01; M _n (¹ H): no olefins	2.1
247	7a	25	B(C ₆ F ₅) ₃	2.19	3,790	M _n (¹ H): 4,160	11.6
248	7a	80	B(C ₆ F ₅) ₃	1.36	2,030	MI: 35; M _n (¹ H): 1,370	35.7
249	8a	25	BPh ₃	3.88	6,400	MI: 120; M _n (¹ H): 2,990	57.2
250	8a	25	B(C ₆ F ₅) ₃	6.95	11,800	MI: 2.6; M _n (¹ H): 6,770	57.5
251	8a	80	B(C ₆ F ₅) ₃	3.99	7,220	MI: 132	

- 5 ^aTwo equiv. ^bTO: number of turnovers per metal center = (moles ethylene consumed, as determined by the weight of the isolated polymer or oligomers) divided by (moles catalyst). Calculations are based upon the exact amount of catalyst used. ^cM.W.: Molecular weight of the polymer or oligomers as determined by melt index (MI: g/10 min at 190 °C), GPC (molecular weights are reported versus polystyrene standards; conditions: Waters 150C, trichlorobenzene at 150 °C, Shodex columns at-806MS 4G 734/602005, RI detector), and/or ¹H NMR (olefin end group analysis). ^dTotal number of methyl groups per 1000 methylene groups as determined by ¹H NMR analysis. ^ePE was not obtained in isolable quantities. ^f0.02 mmol unless noted otherwise. ^g0.015 mmol. ^h0.06 mmol. ⁱ0.04 mmol.
- 10

Table 10 (Cont'd)
Ethylene Polymerizations at 6.9 MPa Pressure Tube Loaded in the Drybox under N₂ Atmosphere
(Trichlorobenzene (5 mL), 18 h)

Ex.	Cmpd ^f	Temp (°C)	Lewis Acid ^a	PE(g)	PE(TO) ^b	M.W. ^c (MI, GPC, and/or ¹ H NMR)	Total Me ^d
252	9a	25	BPh ₃	6.35	11,200	MI > 200; M _n (¹ H): 4,910	64.9
253	9a	25	B(C ₆ F ₅) ₃	6.32	9,900	MI: 102; M _n (¹ H): 5,380	91.3
254	9a	80	B(C ₆ F ₅) ₃	4.8	8,000	M _n (¹ H): 1,410	134.6
255	10a	25	BPh ₃	0.18	320		
256	10a	80	BPh ₃	1.33	2,140	MI: 63; M _n (¹ H): 11,100	38.3
257	10a	80	B(C ₆ F ₅) ₃	0.097	170	M _n (¹ H): 2,010	30.4
258	11a	25	BPh ₃	0.11	190		
259	11a	80	BPh ₃	1.33	2,140	MI: 160; M _n (¹ H): 7,990	40.5
260	12a	25	BPh ₃	3.68	6,040	MI < 0.01	
261	12a	80	BPh ₃	4.22	7,260	MI: 74; M _n (¹ H): 9,260	33.0
262	12a	80	B(C ₆ F ₅) ₃	1.61	2,870	MI: 30; M _n (¹ H): 12,700	19.3
263	13a	25	BPh ₃	0.99	1,690	MI: 0.04; M _n (¹ H): 23,400	20.5
264	13a	80	BPh ₃	3.73	6,580	MI: 147; M _n (¹ H): 4,890	40.2
265	13a	80	B(C ₆ F ₅) ₃	0.93	1,560	MI > 200; M _n (¹ H): 4,520	36.5
266	14a	25	BPh ₃	1.68	3,120	MI: 0.3; M _n (¹ H): 18,300	24.2
267	14a	25	B(C ₆ F ₅) ₃	4.28	7,010	MI: 6; M _n (¹ H): 5,820	42.6
268	14a	80	B(C ₆ F ₅) ₃	1.52	2,760	MI: 117; M _n (¹ H): 3,080	54.0
269	15a	25	BPh ₃	0.265	468 ^e		
270	15a	25	BPh ₃	1.75	3,060	MI: 0.1; M _n (¹ H): 1,900	30.7
271	15a	80	B(C ₆ F ₅) ₃	0.399	705	M _n (¹ H): 1,700	43.7
272	17a	25	BPh ₃	0.191	346	M _n (¹ H): 23,500	21.1
273	17a	25	B(C ₆ F ₅) ₃	5.69	10,100	MI < 0.01; M _n (¹ H): 24,600	10.4
274	17a	80	B(C ₆ F ₅) ₃	1.59	2,540	MI: 0.08; M _n (¹ H): 7,130	24.1

- 5 ^aTwo equiv. ^bTO: number of turnovers per metal center = (moles ethylene consumed, as determined by the weight of the isolated polymer or oligomers) divided by (moles catalyst). Calculations are based upon the exact amount of catalyst used. ^cM.W.: Molecular weight of the polymer or oligomers as determined by melt index (MI: g/10 min at 190°C), GPC (molecular weights are reported versus polystyrene standards; conditions: Waters 150C, trichlorobenzene at 150 °C, Shodex columns at-806MS 4G 734/602005, RI detector), and/or ¹H NMR (olefin end group analysis). ^dTotal number of methyl groups per 1000 methylene groups as determined by ¹H NMR analysis. ^ePE was not obtained in isolable quantities. ^f0.02 mmol unless noted otherwise. ^g0.015 mmol. ^h0.06 mmol.
- 10

Table 10 (Cont'd)
Ethylene Polymerizations at 6.9 MPa Pressure Tube Loaded in the Drybox under N₂ Atmosphere
(Trichlorobenzene (5 mL), 18 h)

Ex.	Cmpd ^f	Temp (°C)	Lewis Acid ^a	PE(g)	PE(TO) ^b	M.W. ^c (MI, GPC, and/or ¹ H NMR)	Total Me ^d
275	18a	25	BPh ₃	e	e		
276	18a	80	B(C ₆ F ₅) ₃	0.046	76	M _n (¹ H): 4,690	27.4
277	19a	25	BPh ₃	0.289	544	M _n (¹ H): 4,450	36.2
278	19a	25	B(C ₆ F ₅) ₃	0.223	399	M _n (¹ H): 1,660	27.8
279	19a	80	BPh ₃	0.077	128	M _n (¹ H): 2,550	39.3
280	19a	80	B(C ₆ F ₅) ₃	0.224	399	M _n (¹ H): 839	52.5
281	21a	25	BPh ₃	6.48	10,700	MI: 42; M _n (¹ H): 21,400	24.9
282	21a	80	BPh ₃	3.44	6,090	MI > 200; M _n (¹ H): 4,010	52.5
283	21a	80	B(C ₆ F ₅) ₃	0.123	226		
284	21b	25	BPh ₃	4.15	6,060	MI: 16.5; M _n (¹ H): 21,600	19.9
285	21b	25	B(C ₆ F ₅) ₃	0.024	31	M _n (¹ H): 1,570	34.2
286	21b	80	BPh ₃	3.39	5,640	MI > 200; M _n (¹ H): 3,730	55.2
287	21b	80	B(C ₆ F ₅) ₃	0.030	48	M _n (¹ H): 2,190	38.7
288	22a	25	BPh ₃	10.1	17,900	MI > 200; M _n (¹ H): 2,600	85.1
289	22a	80	BPh ₃	4.11	7,120	M _n (¹ H): 1,630	92.6
290	22a	80	B(C ₆ F ₅) ₃	0.15	260	M _n (¹ H): no olefins	23.7
291	23a	25	BPh ₃	2.93	4,770	MI > 200; M _n (¹ H): 7,220	59.1
292	23a	25	BPh ₃	2.90	4,960	MI: 120; M _n (¹ H): 8,950	56.5
293	23a	80	B(C ₆ F ₅) ₃	e	e		
294	24a	25	BPh ₃	1.73	3,250	MI<0.01; M _n (¹ H): no olefins	8.6
295	24a	80	BPh ₃	1.95	3,340	MI: 29; M _n (¹ H): 8,110	28.6
296	24a	80	B(C ₆ F ₅) ₃	1.16	2,060	MI: 70; M _n (¹ H): 8,540	23.0
297	25a	25	BPh ₃	9.07	17,000	MI: 1.4	
298	25a	80	BPh ₃	3.64	6,450	MI > 200; M _n (¹ H): 3,310	54.2
299	25a	80	B(C ₆ F ₅) ₃	0.025	47	M _n (¹ H): 3,140	31.6

- 5 ^aTwo equiv. ^bTO: number of turnovers per metal center = (moles ethylene consumed, as determined by the weight of the isolated polymer or oligomers) divided by (moles catalyst). Calculations are based upon the exact amount of catalyst used. ^cM.W.: Molecular weight of the polymer or oligomers as determined by melt index (MI: g/10 min at 190 °C), GPC (molecular weights are reported versus polystyrene standards; conditions: Waters 150C, trichlorobenzene at 150 °C, Shodex columns at-806MS 4G 734/602005, RI detector), and/or ¹H NMR (olefin end group analysis). ^dTotal number of methyl groups per 1000 methylene groups as determined by ¹H NMR analysis. ^ePE was not obtained in isolable quantities. ^f0.02 mmol unless noted otherwise. ^g0.015 mmol. ^h0.06 mmol.
- 10

Table 10 (Cont'd)
Ethylene Polymerizations at 6.9 MPa Pressure Tube Loaded in the Drybox under N₂ Atmosphere
(Trichlorobenzene (5 mL), 18 h)

Ex.	Cmpd ^f	Temp (°C)	Lewis Acid ^a	PE(g)	PE(TO) ^b	M.W. ^c (MI, GPC, and/or ¹ H NMR)	Total Me ^d
300	26a	25	BPh ₃	7.89	13,700	MI > 200; M _n (¹ H): 3,250	69.2
301	26a	25	BPh ₃	11.7	17,900	MI > 200; M _n (¹ H): 3,930	66.6
302	26a	80	B(C ₆ F ₅) ₃	e	e		
303	27a	25	BPh ₃	4.47	7,800	MI: 210; M _n (¹ H): 8,040	52.7
304	27a	25	BPh ₃	7.03	11,500	MI: 108; M _n (¹ H): 8,230	50.9
305	27a	80	B(C ₆ F ₅) ₃	0.009	17	M _n (¹ H): 5,070	27.9
306	28a	25	BPh ₃	0.761	1,300	MI: 60; M _n (¹ H): 19,900	37.1
307	28a	25	BPh ₃	0.271	481	M _n (¹ H): 26,700	31.3
308	28a	80	B(C ₆ F ₅) ₃	0.006	10	M _n (¹ H): 6,630	19.8
309	29a	25	B(C ₆ F ₅) ₃	0.573	994	MI: 0.12; M _n (¹ H): 4,010	16.2
310	29a	25	BPh ₃	e	e		
311	29a	80	B(C ₆ F ₅) ₃	0.199	360	M _n (¹ H): 1,650	35.3
312	30a	25	B(C ₆ F ₅) ₃	2.45	4,160	MI < 0.01; M _n (¹ H): 8,300	8.1
313	30a	25	BPh ₃	e	e		
314	30a	80	B(C ₆ F ₅) ₃	1.64	2,610	MI: 17; M _n (¹ H): 3,600	23.0
315	33a	25	BPh ₃	0.431	768	M _n (¹ H): 21,300	3.4
316	33a	25	B(C ₆ F ₅) ₃	2.35	4,070	MI: 0.13; M _n (¹ H): 4,270	37.1
317	33a	80	B(C ₆ F ₅) ₃	0.915	1,540	MI: 36.8; M _n (¹ H): 1,860	36.1
318	34a	25	B(C ₆ F ₅) ₃	7.53	11,600	M _n (¹ H): 3,450	72.4
319	34a	80	B(C ₆ F ₅) ₃	5.35	7,570	M _w (GPC): 29,100; PDI: 46	113.2
320	36a	25	BPh ₃	9.31	15,300	M _w (GPC): 461,000; PDI: 3.3	8.0
321	36a	80	BPh ₃	0.353	564	M _w (GPC): 30,000; PDI: 4.0	25.8
322	37a	25	BPh ₃	0.919	1,650	MI: 0.06; M _n (¹ H): no olefins	14.4
323	37a	25	BPh ₃	0.299	434	M _n (¹ H): 31,100	15.0
324	37a	80	B(C ₆ F ₅) ₃	0.269	434	M _n (¹ H): 5,200	40.4

- 5 ^aTwo equiv. ^bTO: number of turnovers per metal center = (moles ethylene consumed, as determined by the weight of the isolated polymer or oligomers) divided by (moles catalyst). Calculations are based upon the exact amount of catalyst used. ^cM.W.: Molecular weight of the polymer or oligomers as determined by melt index (MI: g/10 min at 190 °C), GPC (molecular weights are reported versus polystyrene standards; conditions: Waters 150C, trichlorobenzene at 150 °C, Shodex columns at-806MS 4G 734/602005, RI detector), and/or ¹H NMR (olefin end group analysis). ^dTotal number of methyl groups per 1000 methylene groups as determined by ¹H NMR analysis. ^ePE was not obtained in isolable quantities. ^f0.02 mmol unless noted otherwise. ^g0.015 mmol. ^h0.06 mmol.
- 10
- 15

Table 10 (Cont'd)
Ethylene Polymerizations at 6.9 MPa Pressure Tube Loaded in the Drybox under N₂ Atmosphere
(Trichlorobenzene (5 mL), 18 h)

Ex.	Cmpd ^f	Temp (°C)	Lewis Acid ^a	PE(g)	PE(TO) ^b	M.W. ^c (MI, GPC, and/or ¹ H NMR)	Total Me ^d
325	38a	25	BPh ₃	1.43	2,470	MI: 111; M _n (¹ H): 6,150	65.8
326	38a	80	BPh ₃	1.55	2,580	MI > 200; M _n (¹ H): 2,780	99.2
327	39a	25	B(C ₆ F ₅) ₃	0.414	814	M _n (¹ H): 10,700	7.7
328	39a	25	BPh ₃	e	e		
329	39a	25	BPh ₃	e	e		
330	39a	80	B(C ₆ F ₅) ₃	0.758	1,290	MI: 80; M _n (¹ H): 5,190	20.1
331	41a	25	BPh ₃	0.316	586	M _n (¹ H): no olefins	11.5
332	41a	25	B(C ₆ F ₅) ₃	4.08	6,690	MI < 0.01; M _n (¹ H): 30,700	30.9
333	41a	80	B(C ₆ F ₅) ₃	2.26	3,730	MI: 180; M _n (¹ H): 9,960	36.9
334	43a	25	BPh ₃	e	e		
335	43a	25	B(C ₆ F ₅) ₃	0.53	918	M _n (¹ H): 3,600	36.6
336	43a	80	BPh ₃	e	e		
337	43a	80	B(C ₆ F ₅) ₃	0.054	93	M _n (¹ H): 2,960	32.0
338	44a	25	B(C ₆ F ₅) ₃	0.167	291	M _w (GPC): 136,000; PDI: 18	25.4
339	44a	80	B(C ₆ F ₅) ₃	0.019	34	M _n (¹ H): 5,150	43.3
340	45a	25	B(C ₆ F ₅) ₃	0.026	43	M _n (¹ H): 5,150	8.6
341	45a	80	B(C ₆ F ₅) ₃	trace	trace	M _n (¹ H): 6,310	14.2

- 5 ^aTwo equiv. ^bTO: number of turnovers per metal center = (moles ethylene consumed, as determined by the weight of the isolated polymer or oligomers) divided by (moles catalyst). Calculations are based upon the exact amount of catalyst used. ^cM.W.: Molecular weight of the polymer or oligomers as determined by melt index (MI: g/10 min at 190 °C), GPC (molecular weights are reported versus polystyrene standards; conditions: Waters 150C, trichlorobenzene at 150 °C, Shodex columns at-806MS 4G 734/602005, RI detector), and/or ¹H NMR (olefin end group analysis). ^dTotal number of methyl groups per 1000 methylene groups as determined by ¹H NMR analysis. ^ePE was not obtained in isolable quantities. ^f0.02 mmol unless noted otherwise. ^g0.015 mmol. ^h0.06 mmol.
- 10

Table 11

Ethylene Polymerizations at 6.9 MPa Pressure Tube Loaded in the Drybox under N₂ Atmosphere
(*p*-Xylene, (5 mL), 18 h)

Ex.	Cmpd ^f	Temp (°C)	Lewis Acid ^a	PE(g)	PE(TO) ^b	M.W. ^c (MI, GPC, and/or ¹ H NMR)	Total Me ^d
342	3a ^h	25	BPh ₃	20.2	12,000	MI: 2.6	
343	3a ^g	25	BPh ₃	0.19	366		
344	3a ^g	25	B(C ₆ F ₅) ₃	0.48	1,160	M _n (¹ H): 27,100	24.4
345	6a ^h	80	BPh ₃	11.1	6,610	MI: 105; M _n (¹ H): 9,090	31.1
346	6a ^h	80	B(C ₆ F ₅) ₃	6.90	4,100	MI: >200; M _n (¹ H): 3,170	63.4
347	6a ^g	80	B(C ₆ F ₅) ₃	3.47	8,470	MI: 58.8; M _n (¹ H): 6,880	34.5

^aTwo equiv. ^bTO: number of turnovers per metal center = (moles ethylene consumed, as determined by the weight of the isolated polymer or oligomers) divided by (moles catalyst). Calculations are based upon the exact amount of catalyst used. ^cM.W.: Molecular weight of the polymer or oligomers as determined by melt index (MI: g/10 min at 190 °C), GPC (molecular weights are reported versus polystyrene standards; conditions: Waters 150C, trichlorobenzene at 150 °C, Shodex columns at-806MS 4G 734/602005, RI detector), and/or ¹H NMR (olefin end group analysis). ^dTotal number of methyl groups per 1000 methylene groups as determined by ¹H NMR analysis. ^ePE was not obtained in isolable quantities. ^f0.02 mmol unless noted otherwise. ^g0.015 mmol. ^h0.06 mmol.

Table 12

Ethylene Polymerizations at 6.9 MPa Pressure Tube Loaded in the Drybox under N₂ Atmosphere
(Cyclohexane, (5 mL), 18 h)

Ex.	Cmpd ^f	Temp (°C)	Lewis Acid ^a	PE(g)	PE(TO) ^b	M.W. ^c (MI, GPC, and/or ¹ H NMR)	Total Me ^d
348	3a ^g	25	BPh ₃	0.52	1,160		
349	6a ^h	80	BPh ₃	10.6	6,270	MI: 135; M _n (¹ H): 7,410	33.8
350	6a ^g	80	BPh ₃	7.07	16,810	MI: 129; M _n (¹ H): 8,800	27.7

^aTwo equiv. ^bTO: number of turnovers per metal center = (moles ethylene consumed, as determined by the weight of the isolated polymer or oligomers) divided by (moles catalyst). Calculations are based upon the exact amount of catalyst used. ^cM.W.: Molecular weight of the polymer or oligomers as determined by melt index (MI: g/10 min at 190 °C), GPC (molecular weights are reported versus polystyrene standards; conditions: Waters 150C, trichlorobenzene at 150 °C, Shodex columns at-806MS 4G 734/602005, RI detector), and/or ¹H NMR (olefin end group analysis). ^dTotal number of methyl groups per 1000 methylene groups as determined by ¹H NMR analysis. ^ePE was not obtained in isolable quantities. ^f0.02 mmol unless noted otherwise. ^g0.015 mmol. ^h0.06 mmol.

Table 13
Ethylene Polymerizations at 1.4 MPa
Pressure Tube Loaded in the Drybox under N₂ Atmosphere
(Trichlorobenzene (5 mL), 0.02 mmol Cmpd, 18 h)

5

Ex.	Cmpd	Temp (°C)	Lewis Acid ^a	PE(g)	PE(TO) ^b	M.W. ^c (MI, GPC, and/or ¹ H NMR)	Total Me ^d
351	3a	25	BPh ₃	1.71	2,540	MI: 0.26; M _n (¹ H): 64,600	17.3
352	4a	25	BPh ₃	2.87	5,000	MI: 92; M _n (¹ H): 15,300	40.3
353	6a	25	B(C ₆ F ₅) ₃	2.31	3,760	MI: 1; M _n (¹ H): 11,700	55.0
354	8a	25	B(C ₆ F ₅) ₃	2.10	3,440	MI: 123; M _n (¹ H): 5,570	81.5
355	9a	25	B(C ₆ F ₅) ₃	1.53	2,730	M _n (¹ H): 4,850	112.3
356	14a	25	B(C ₆ F ₅) ₃	1.18	2,080	MI: 7.5; M _n (¹ H): 4,730	53.3
357	21a	25	BPh ₃	1.58	2,670	MI: 1.5; M _n (¹ H): 14,700	39.9
358	22a	25	BPh ₃	2.94	4740	MI > 200; M _n (¹ H): 4,580	73.7
359	25a	25	BPh ₃	1.18	2,060	MI: 6.6; M _n (¹ H): 5,020	110.6
360	26a	25	BPh ₃	2.41	4,040	MI > 200; M _n (¹ H): 3,870	73.6

^aTwo equiv. ^bTO: number of turnovers per metal center = (moles ethylene consumed, as determined by the weight of the isolated polymer or oligomers) divided by (moles catalyst). Calculations are based upon the exact amount of catalyst used. ^cM.W.: Molecular weight of the polymer or oligomers as determined by melt index (MI: g/10 min at 190 °C), GPC (molecular weights are reported versus polystyrene standards; conditions: Waters 150C, trichlorobenzene at 150 °C, Shodex columns at-806MS 4G 734/602005, RI detector), and/or ¹H NMR (olefin end group analysis). ^dTotal number of methyl groups per 1000 methylene groups as determined by ¹H NMR analysis. ^ePE was not obtained in isolable quantities.

10

Table 14
Ethylene Polymerizations Using Nickel Methyl Initiators:
Effect of Lewis Acid on Initiation/Productivity
(6.9 MPa, 0.02 mmol Cmpd, Trichlorobenzene (5 mL), 18 h)

5

Ex.	Cmpd	Temp (°C)	Lewis Acid (equiv)	PE(g)	PE(TO) ^a	M.W. ^b (MI, GPC, and/or ¹ H NMR)	Total Me ^c
361	50 ^d	25	none	trace	trace		
362	50 ^d	80	none	0.189	307	M _n (¹ H): 5,840	39.4
363	50	25	BPh ₃ (2)	0.126	201		
364	50	80	B(C ₆ F ₅) ₃ (2)	0.074	124		
365	50	25	BPh ₃ (10)	4.41	7,590		
366	50	80	BPh ₃ (10)	3.01	5,220	M _w (GPC):17,900;PDI:6	

^aTO: number of turnovers per metal center = (moles ethylene consumed, as determined by the weight of the isolated polymer or oligomers) divided by (moles catalyst). Calculations are based upon the exact amount of catalyst used. ^bM.W.: Molecular weight of the polymer or oligomers as determined by melt index (MI: g/10 min at 190 °C), GPC (molecular weights are reported versus polystyrene standards; conditions: Waters 150C, trichlorobenzene at 150 °C, Shodex columns at-806MS 4G 734/602005, RI detector), and/or ¹H NMR (olefin end group analysis). ^cTotal number of methyl groups per 1000 methylene groups as determined by ¹H NMR analysis. ^dUnder the same reaction conditions (e.g., no Lewis acid present), nickel compounds 51 - 54 gave analogous results: no polymer was isolated, but the ¹H NMR spectra showed a

10

15 -(CH₂)_n- resonance.

Examples 367 - 369Cyclopentene OligomerizationsGeneral Procedure for Cyclopentene

Oligomerizations. In the drybox under a nitrogen atmosphere, the nickel compound (0.03 mmol) was placed in a vial. Next, 5 mL of toluene was added to the vial followed by 1.3 mL of cyclopentene. $B(C_6F_5)_3$ (40 mg) was then added to the vial. The reaction mixture was mixed for 3 d on a vortexer and then removed from the drybox and added to 100 mL of stirring methanol. No polymer precipitated. GC analysis was carried out on the organic layer. The results are reported in Table 15 below.

Table 15Cyclopentene Oligomerizations

Ex.	Cmpd	GC Analysis
367	31a	dimers through heptamers observed
368	32a	dimers through heptamers observed
369	47b	dimers through heptamers observed

Examples 370 - 375Ethylene/Ethyl 4-Pentenoate PolymerizationsGeneral Procedure for Ethylene/Ethyl 4-Pentenoate

Polymerizations. In a nitrogen-filled drybox, the
 5 nickel compound (0.06 mmol) and the Lewis acid (5
 equiv) were placed together in a glass insert. The
 insert was cooled to -30 °C in the drybox freezer. 5
 mL of cold ethyl 4-pentenoate was added to the cold
 insert, and the insert was recooled in the drybox
 10 freezer. The cold inserts were removed from the drybox
 and placed under a nitrogen purge in a pressure tube,
 which was then sealed and pressurized to 6.9 MPa of
 ethylene and mechanically shaken for 18 h. The
 pressure was then released and the glass insert was
 15 removed from the pressure tube and the polymer was
 precipitated in MeOH, collected on a frit, and dried in
 vacuo. Characteristic NMR resonances of the copolymer
 include the 4.01 OCH₂ resonance in the ¹H NMR and the
 59.7 OCH₂ resonance and ~172.4 C=O resonances in the ¹³C
 20 NMR spectrum.

Table 16Ethylene/Ethyl 4-Pentenoate (E-4-P) Polymerizations

Ex.	Cmpd	Lewis Acid	Temp (°C)	Polymer (g)	DSC/GPC
370	3a	BPh ₃	25	2.35	DSC: T _m = 111 °C
		¹³ C NMR: 0.59 mole percent E-4-P Incorp.; Branching per 1000 CH ₂ 's: Total methyls (27.3), Methyl (23.7), Ethyl (1.7), Propyl (0), Butyl (0.8), Amyl (2.4), Hex and greater and end of chains (5.4), Am and greater and end of chains (1.9), Bu and greater and end of chains (1.8)			
371	21a	BPh ₃	25	0.586	DSC: T _m = 115 °C
		¹³ C NMR: 0.26 mole percent E-4-P Incorp.; Branching per 1000 CH ₂ 's: Total methyls (25.0), Methyl (19.3), Ethyl (2.1), Propyl (0.0), Butyl (1.2), Amyl (0.3), Hex and greater and end of chains (3.1), Am and greater and end of chains (4.1), Bu and greater and end of chains 3.6)			

25

Table 16 (Cont'd)
Ethylene/Ethyl 4-Pentenoate (E-4-P) Polymerizations

Ex.	Cmpd	Lewis Acid	Temp (°C)	Polymer (g)	DSC/GPC
372	8a	B(C ₆ F ₅) ₃	25	0.254	DSC: T _m = 124 °C, 96 °C
		¹³ C NMR: 0.64 mole percent E-4-P Incorp.; Branching per 1000 CH ₂ 's: Total methyls (47.8), Methyl (35.8), Ethyl (3.7), Propyl (0.0), Butyl (3.1), Amyl (3.8), Hex and greater and end of chains (8.7), Am and greater and end of chains (10.2), Bu and greater and end of chains (8.3)			
373	3a	BPh ₃	80	0.468	
		¹³ C NMR: 1.94 mole percent E-4-P Incorp.; Branching per 1000 CH ₂ 's: Total methyls (67.0), Methyl (50.7), Ethyl (6.3), Propyl (0.0), Butyl (3.7), Amyl (7.3), Hex and greater and end of chains (18.6), Am and greater and end of chains (8.4), Bu and greater and end of chains (9.9)			
374	21a	BPh ₃	80	0.312	
		¹³ C NMR: 1.67 mole percent E-4-P Incorp.; Branching per 1000 CH ₂ 's: Total methyls (73.9), Methyl (47.9), Ethyl (9.2), Propyl (0.0), Butyl (0.0), Amyl (6.1), Hex and greater and end of chains (16.2), Am and greater and end of chains (15.7), Bu and greater and end of chains (16.8)			
375	8a	B(C ₆ F ₅) ₃	80	0.232	GPC (THF, 35 °C): M _w = 5,130, PDI = 1.7; DSC: T _m : 117 °C, 46 °C
		¹ H NMR: 1.6 mole percent E-4-P Incorp.; Branching per 1000 CH ₂ 's: Total methyls (94)			

5

Examples 376-381

General Procedure for Ethylene Polymerizations of Table
17:

Ethylene Polymerizations in the Parr® Reactor

Procedure. Prior to conducting the
 10 polymerization, the Parr® reactor flushed with
 nitrogen, heated under vacuum overnight, and then
 allowed to cool to room temperature. In the drybox, a
 glass vial was loaded with the nickel compound, Lewis
 acid and solvent and then capped with a rubber septum.

The solution of the nickel complex and Lewis acid was then transferred to a 100 mL Parr reactor under vacuum, and the reactor was pressurized with ethylene and the reaction mixture was mechanically stirred. After the stated reaction time, the ethylene pressure was released, and the polymer was precipitated by adding the reaction mixture to a solution of MeOH (~100 mL) and concentrated HCl (~1-3 mL). The polymer was then collected on a frit and rinsed with HCl, MeOH, and acetone. The polymer was transferred to a pre-weighed vial and dried under vacuum overnight. The polymer yield and characterization were then obtained.

Table 17
Ethylene Polymerizations in the Parr Reactor
(0.02 mmol Cmpd, Trichlorobenzene (35 mL))

Ex.	Cmpd	Time (h)	Press. (MPa)	LewisAcid (equiv)	PE(g)	PE(TO) ^a	M.W. ^b (MI, GPC, and/or ¹ H NMR)	Total Me ^c
376	6a	9.9	5.5	B(C ₆ F ₅) ₃ /2	7.46	12,400	M _n (¹ H):no olefins	34.4
377	6a	0.5	5.5	B(C ₆ F ₅) ₃ /2	3.5	5,940	M _n (¹ H):no olefins	40.3
378	6a	6.5	5.5	B(C ₆ F ₅) ₃ /2	9.30	15,500	M _n (¹ H):no olefins	39.2
379	6a	4.8	1.4	B(C ₆ F ₅) ₃ /2	0.26	394	M _n (¹ H):no olefins	32.6
380	3a	6.0	3.5	BPh ₃ /5	3.57	5,560	M _n (¹ H):no olefins	19.1
381	6a	6.6	3.5	B(C ₆ F ₅) ₃ /5	1.52	2,480	M _n (¹ H):no olefins	29.0

^aTO: number of turnovers per metal center = (moles ethylene consumed, as determined by the weight of the isolated polymer or oligomers) divided by (moles catalyst). Calculations are based upon the exact amount of catalyst used. ^bM.W.: Molecular weight of the polymer or oligomers as determined by melt index (MI: g/10 min at 190 °C), GPC (molecular weights are reported versus polystyrene standards; conditions: Waters 150C, trichlorobenzene at 150 °C, Shodex columns at-806MS 4G 734/602005, RI detector), and/or ¹H NMR (olefin end group analysis). ^cTotal number of methyl groups per 1000 methylene groups as determined by ¹H NMR analysis. ^dUnder the same reaction conditions (e.g., no Lewis acid present), nickel compounds 51 - 54 gave analogous results: no polymer was isolated, but the ¹H NMR spectra showed a -(CH₂)_n- resonance.

Examples 382-437

General Procedure for Ethylene (28-35 kPa)

Polymerizations of Table 18

Procedure. In the drybox, a glass Schlenk flask was loaded with the nickel compound, Lewis acid, solvent and a stir bar. The flask was then capped with a rubber septum and the stopcock was closed prior to

removing the flask from the drybox. The flask was then attached to the ethylene line where it was evacuated and backfilled with ethylene. The reaction mixture was stirred under ethylene for the stated reaction time,
5 the ethylene pressure was then released, and the polymer was precipitated by adding the reaction mixture to a solution of MeOH (~100 mL) and concentrated HCl (~1-3 mL). The polymer was then collected on a frit and rinsed with MeOH. The polymer was transferred to a
10 pre-weighed vial and dried under vacuum overnight. The polymer yield and characterization were then obtained.

Table 18

Ethylene Polymerizations at 28-35 kPa Ethylene

Ex.	Cmpd	Lewis Acid (equiv)	Time (h)	Solvent (mL) ^b	PE(g)	PE(TO)
382	1a	B(C ₆ F ₅) ₃ /20	25.0	Toluene (35)	<i>a</i>	<i>a</i>
383	1a	MAO-IP/90	0.5	Toluene (35)	0.924	1,040
Description: White rubbery solid.						
384	2a	MAO-IP/86	0.5	Toluene (35)	0.534	577
Description: White, soft, slightly rubbery solid.						
385	3a	BPh ₃ /5	26.3	Toluene (35)	<i>a</i>	<i>a</i>
386	3a	BPh ₃ /20	23.5	Toluene (35)	0.662	787
Description: Slightly sticky, clear, colorless amorphous solid.						
¹ H NMR (C ₆ D ₆ , rt) 99.6 total Me/1000CH ₂						
387	3a	BPh ₃ /50	23.5	Toluene (35)	0.110	131
Description: Clear, colorless sticky viscous oil.						
¹ H NMR (C ₆ D ₆ , rt) 98.6 total Me/1000CH ₂						
388	3a	BPh ₃ /100	23.5	Toluene (35)	0.021	25
Description: Light yellow, clear amorphous solid/oil.						
¹ H NMR (C ₆ D ₆ , rt) 102.7 total Me/1000CH ₂						
389	3a	B(C ₆ F ₅) ₃ /20	32.4	Toluene (35)	0.042	50
Description: White powder.						
390	3a	BF ₃ ·Et ₂ O/50	25.5	Toluene (35)	<i>a</i>	<i>a</i>
391	4a	BPh ₃ /50	23.5	Toluene (35)	0.261	310
Description: Clear, amorphous gummy solid.						
¹ H NMR (C ₆ D ₆ , rt) 107.4 total Me/1000CH ₂						

^aOnly a trace of polymer or no polymer was isolated. ^b1,2,4-Trichlorobenzene is abbreviated as 1,2,4-TCB.

Table 18 (Cont'd)

Ethylene Polymerizations at 28-35 kPa Ethylene

Ex.	Cmpd	Lewis Acid (equiv)	Time (h)	Solvent (mL) ^b	PE(g)	PE(TO)
392	4a	BPh ₃ /100	37.2	Toluene (35)	0.797	950
Description: Soft, white powder/solid.						
393	5a	BPh ₃ /5	26.3	Toluene (35)	<i>a</i>	<i>a</i>
394	5a	BPh ₃ /50	23.5	Toluene (35)	0.054	64
Description: White slightly sticky, partially amorphous solid.						
395	5a	BPh ₃ /50	26.4	Toluene (35)	0.065	77
Description: Clear/white partial powder/partial amorphous solid.						
396	6a	B(C ₆ F ₅) ₃ /5	26.4	Toluene (35)	0.15	180
Description: Brown sticky amorphous solid. ¹ H NMR (C ₆ D ₆ , rt): 105.4 Total Me/1000 CH ₂						
397	6a	B(C ₆ F ₅) ₃ /20	26.4	Toluene (35)	7.38	8,760
Description: White, slightly rubbery or spongy powder. ¹³ C NMR: Branching per 1000 CH ₂ 's. Total methyls (59.8), methyl (38.5), ethyl (10.4), propyl (1.6), butyl (2.4), hexyl and greater and end of chains (7.0), amy and greater and end of chains (7.9), butyl and greater and end of chains (9.3).						
398	6a	BPh ₃ /100	17.0	Toluene (35)	0.17	200
Description: White soft powder.						
399	6a	BF ₃ ·Et ₂ O/50	25.5	Toluene (35)	<i>a</i>	<i>a</i>
400	6a	Al(O- <i>i</i> -Pr) ₃ /20	22.4	Toluene (35)	<i>a</i>	<i>a</i>
401	6a	PMAO-IP/28	25.1	Toluene (35)	<i>a</i>	<i>a</i>

^aOnly a trace of polymer or no polymer was isolated. ^b1,2,4-Trichlorobenzene is abbreviated as

1,2,4-TCB.

5

Table 18 (Cont'd)

Ethylene Polymerizations at 28-35 kPa Ethylene

Ex.	Cmpd	Lewis Acid (equiv)	Time (h)	Solvent (mL) ^b	PE(g)	PE(TO)
402	7a	B(C ₆ F ₅) ₃ /20	24.1	Toluene (35)	1.04	1,180
Description: White powder.						
403	8a	B(C ₆ F ₅) ₃ /5	25.4	Toluene (35)	1.45	1,730
Soft partial powder/partial amorphous solid. ¹ H NMR (C ₆ D ₆ , rt): 118.3 Total Me/1000 CH ₂						
404	8a	BPh ₃ /100	17.0	Toluene (35)	0.016	19
Description: Tan powder.						
405	8a	B(C ₆ F ₅) ₃ /20	23.1	Toluene (35)	2.82	3,350
Description: Brown amorphous sticky solid. ¹ H NMR (C ₆ D ₆ , rt): 143.0 Total Me/1000 CH ₂						
406	9a	B(C ₆ F ₅) ₃ /5	26.4	Toluene (35)	0.018	21
Description: Brown partial oil, partial amorphous solid.						
407	9a	B(C ₆ F ₅) ₃ /20	23.1	Toluene (35)	6.99	8,300
Description: Brown amorphous sticky solid. ¹ H NMR (C ₆ D ₆ , rt): 174.4 Total Me/1000 CH ₂						
408	10a	BPh ₃ /20	24.2	Toluene (35)	1.43	1,700
Description: White powder.						
409	12a	BPh ₃ /20	25.0	Toluene (35)	0.749	890
Description: White powder.						
410	12a	B(C ₆ F ₅) ₃ /10	22.5	Toluene (35)	a	a
411	14a	B(C ₆ F ₅) ₃ /20	25.5	Toluene (35)	0.97	1,150
Description: White, stringy powder						

^aOnly a trace of polymer or no polymer was isolated. ^b1,2,4-Trichlorobenzene is abbreviated as 1,2,4-TCB.

5

Table 18 (Cont'd)

Ethylene Polymerizations at 28-35 kPa Ethylene

Ex.	Cmpd	Lewis Acid (equiv)	Time (h)	Solvent (mL) ^b	PE(g)	PE(TO)
412	15a	B(C ₆ F ₅) ₃ /10	22.5	Toluene (35)	0.106	126
Description: Slightly rubbery off-white solid.						
413	17a	B(C ₆ F ₅) ₃ /20	25.5	Toluene (35)	2.08	2,470
Description: Soft white powder.						
414	21a	BPh ₃ /5	25.4	Toluene (35)	1.88	2,230
Description: White, somewhat rubbery powder.						
415	21a	BPh ₃ /20	26.4	Toluene (35)	1.73	2,060
Description: White powder.						
416	21a	BPh ₃ /50	26.4	Toluene (35)	0.631	750
Description: White powder.						
417	21a	BPh ₃ /100	21.4	1,2,4-TCB (20)	0.474	563
Description: White powder.						
418	21b	BPh ₃ /100	21.4	1,2,4-TCB (20)	0.156	185
419	22a	BPh ₃ /100	37.2	Toluene (35)	0.777	920
Description: White powder.						
420	23a	BPh ₃ /20	26.0	Toluene (35)	0.409	473
Description: Almost clear, sticky amorphous oil/solid.						
421	24a	B(C ₆ F ₅) ₃ /10	22.5	Toluene (35)	<i>a</i>	<i>a</i>

^aOnly a trace of polymer or no polymer was isolated. ^b1,2,4-Trichlorobenzene is abbreviated as 1,2,4-TCB.

5

Table 18 (Cont'd)

Ethylene Polymerizations at 28035 kPa Ethylene

Ex.	Cmpd	Lewis Acid (equiv)	Time (h)	Solvent (mL) ^b	PE(g)	PE(TO)
422	24a	BPh ₃ /50	22.4	Toluene (35)	0.374	444
Description: White powder.						
423	25a	BPh ₃ /50	24.2	Toluene (35)	1.47	1,750
Description: White, slightly rubbery powder.						
424	27a	BPh ₃ /20	26.0	Toluene (35)	0.856	992
Description: Amorphous, slightly sticky, waxy, clear solid.						
¹ H NMR (C ₆ D ₆ , rt) 90.0 total Me/1000CH ₂						
425	30a	B(C ₆ F ₅) ₃ /20	24.2	Toluene (25)	0.65	770
Description: White powder.						
426	34a	B(C ₆ F ₅) ₃ /20	23.1	Toluene (35)	5.75	6,830
Description: Tan amorphous solid. ¹ H NMR (C ₆ D ₆ , rt) 182.0 Total Me/1000 CH ₂ .						
Mn ~1,980						
427	36a	BPh ₃ /20	25.6	Toluene (35)	1.32	1,570
Description: White powder.						
428	36a	B(C ₆ F ₅) ₃ /10	24.3	Toluene (35)	0.11	130
Description: Tan powder.						
429	37a	BPh ₃ /20	23.8	Toluene (35)	0.486	576
430	38a	BPh ₃ /20	26.0	Toluene (35)	0.024	28
Description: Clear, amorphous, very slightly sticky solid						
¹ H NMR (C ₆ D ₆ , rt) 91.2 total Me/1000CH ₂						
431	39a	B(C ₆ F ₅) ₃ /20	22.6	Toluene (20)	0.244	290
Description: White powder.						

^aOnly a trace of polymer or no polymer was isolated. ^b1,2,4-Trichlorobenzene is abbreviated as

5 1,2,4-TCB.

Table 18 (Cont'd)

Ethylene Polymerizations at 28-35 kPa Ethylene

Ex.	Cmpd	Lewis Acid (equiv)	Time (h)	Solvent (mL) ^b	PE(g)	PE(TO)
432	39a	BPh ₃ /200	23.8	Toluene (35)	<i>a</i>	<i>a</i>
433	41a	B(C ₆ F ₅) ₃ /5	25.4	Toluene (35)	0.059	70
Description: White powder.						
434	41a	B(C ₆ F ₅) ₃ /20	22.4	Toluene (35)	1.73	2,060
Description: White powder.						
435	50	BPh ₃ /100	21.4	1,2,4-TCB (20)	1.06	1,260
Description: White powder.						
436	52	BPh ₃ /100	21.4	1,2,4-TCB (20)	1.21	1,440
Description: White powder.						
437	52	BPh ₃ /100	23.1	Toluene (35)	1.40	1,660
Description: White powder.						

5 ^aOnly a trace of polymer or no polymer was isolated. ^b1,2,4-Trichlorobenzene is abbreviated as 1,2,4-TCB.

Example 438Ethylene Polymerization Using (acac)Ni(Et)PPh₃Precursor at 6.9 MPa

10 In the drybox, a glass insert was loaded with (acac)Ni(Et)PPh₃ (26.9 mg, 0.06 mmol) and [2-(NaO)-3,5-(*t*-Bu)₂-C₆H₂-C(Me)=NAr (Ar = 2,6-(*i*-Pr)₂-C₆H₃) · 0.5 THF] (25.8 mg, 1 equiv). The insert was cooled to -35 °C in
 15 the drybox freezer, 5 mL of C₆D₆ was added to the cold insert, and the insert was cooled again. BPh₃ (29.1 mg, 2 equiv) was added to the cold solution, and the insert was then capped and sealed and cooled again. Outside of the drybox, the cold insert was placed under
 20 a nitrogen purge into the pressure tube. The pressure tube was sealed, placed under ethylene (6.9 MPa), and allowed to warm to rt as it was shaken mechanically for approximately 18 h. Polyethylene (16.5 g, 9,820 TO)

was isolated as a powder following precipitation from methanol.

Example 439

Ethylene Polymerization Using NiBr₂ Precursor at 28-35

5

MPa

The sodium salt of the ligand of Example 1 (1.01 g, 2.23 mmol), e.g.

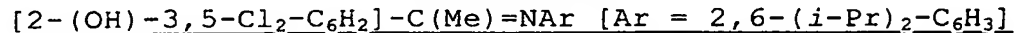


was placed in a round bottom flask in the drybox
10 together with 487 mg (2.23 mmol) of NiBr₂. THF (20 mL)
was added and the solution was stirred for ~2 months.
The THF was removed in vacuo and the product was
dissolved in CH₂Cl₂ and the resulting solution was
filtered. The solvent was removed and the product was
15 dried in vacuo. An orange powder (488 mg) was
isolated. (In addition to CD₂Cl₂, the product was also
soluble in C₆D₆. ¹H NMR spectra in both solvents were
complex.)

In the drybox, a glass Schlenk flask was loaded
20 with the resulting orange nickel compound (17 mg, ~0.03
mmol), 35 mL of toluene and a stir bar. The flask was
then capped with a rubber septum and the stopcock was
closed prior to removing the flask from the drybox.
The flask was then attached to the ethylene line where
25 it was evacuated and backfilled with ethylene. MAO-IP
(2 mL, ~94 equiv) was added to the flask via cannula.
The reaction mixture was stirred under ethylene for 3.5
h, the ethylene pressure was then released, and the
polymer was precipitated by adding the reaction mixture
30 to a solution of MeOH (~100 mL) and concentrated HCl
(~1-3 mL). The polymer was then collected on a frit
and rinsed with MeOH. The polymer was transferred to a
pre-weighed vial and dried under vacuum overnight. A
white polyethylene film (5.09 g, ~6050 TO) was
35 isolated.

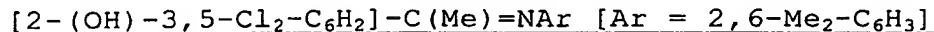
Examples 440-468Ligand Syntheses

Ligand syntheses and deprotonations were carried out according to the general procedures given below and under Examples 1-16 (see above) unless stated otherwise.

Example 440

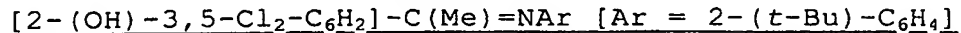
The general procedure for imine synthesis was followed using 10.03 g (48.9 mmol) of 3',5'-dichloro-2'-hydroxyacetophenone and 11.27 g (1.30 equiv) of 2,6-diisopropylaniline. A yellow powder (15.35 g, 86.2%) was isolated: ^1H NMR (CDCl_3) δ 7.46 (d, 1, Ar': H), 7.44 (d, 1, Ar': H), 7.14 (m, 3, Ar: H), 2.64 (septet, 2, CHMe₂), 2.12 (s, 3, N=C(Me)), 1.08 and 1.04 (d, 6 each, CHMeMe').

The sodium salt was synthesized according to the above general procedure: ^1H NMR ($\text{THF}-d_8$): 0.59 equiv of THF coordinated.

Example 441

The general procedure for imine synthesis was followed using 10.681 g (52.1 mmol) of 3',5'-dichloro-2'-hydroxyacetophenone and 8.21 g (1.30 equiv) of 2,6-dimethylaniline. A yellow powder (7.61 g, 47.4) was isolated: ^1H NMR (CDCl_3) δ 7.57 (d, 1, Ar': H), 7.52 (d, 1, Ar': H), 7.15 (d, 2, Ar: H_m), 7.08 (t, 1, Ar: H_p), 2.21 (s, 3, N=CMe), 2.10 (s, 6, Ar: Me).

The sodium salt was synthesized according to the above general procedure: ^1H NMR ($\text{THF}-d_8$): 0.59 equiv of THF coordinated.

Example 442

The general procedure for imine synthesis was followed using 10.41 g (50.8 mmol) of 3',5'-dichloro-2'-hydroxyacetophenone and 9.85 g (1.30 equiv) of 2-*t*-butylaniline. A yellow powder (15.30 g, 89.6%, 2 crops) was isolated: ^1H NMR (CDCl_3) δ 7.55 (d, 1,

Ar': H), 7.52 (d, 1, Ar': H), 7.50 (d, 1, Ar: H), 7.25 (t, 1, Ar: H), 7.22 (t, 1, Ar: H), 6.52 (d, 1, Ar: H), 2.31 (s, 3, Me), 1.36 (s, 9, CMe₃).

The sodium salt was synthesized according to the above general procedure: ¹H NMR (THF-d₈): 0.16 equiv of THF coordinated.

Example 443

[2-(OH)-3,5-Br₂-C₆H₂]-CH=NAr [Ar = 2,6-(i-Pr)₂-C₆H₃]

The general procedure for imine synthesis was followed using 3.23 g (11.5 mmol) of 3,5-dibromosalicylaldehyde and 2.66 g (1.30 equiv) of 2,6-diisopropylaniline. A yellow powder (3.10 g, 61.4%) was isolated: ¹H NMR (CDCl₃) 8.21 (s, 1, N=CH), 7.81 (d, 1, Ar': H), 7.45 (d, 1, Ar': H), 7.22 (s, 3, Ar: H), 2.94 (septet, 2, CHMe₂), 1.18 (d, 12, CHMe₂).

The sodium salt was synthesized according to the above general procedure: ¹H NMR (THF-d₈): 0.7 equiv of THF coordinated.

Example 444

[2-(OH)-3,5-Br₂-C₆H₂]-C(Me)=NAr [Ar = 2,6-(i-Pr)₂-C₆H₃]

The general procedure for imine synthesis was followed using 10.84 g (36.9 mmol) of 3',5'-dibromo-2'-hydroxyacetophenone and 8.50 g (1.30 equiv) of 2,6-diisopropylaniline. A yellow powder (13.16 g, 78.7%) was isolated: ¹H NMR (CDCl₃) δ 7.83 (d, 1, Ar': H), 7.73 (d, 1, Ar': H), 7.26 (m, 3, Ar: H), 2.76 (septet, 2, CHMe₂), 2.24 (s, 3, Me), 1.19 and 1.18 (d, 6 each, CHMeMe').

The sodium salt was synthesized according to the above general procedure: ¹H NMR (THF-d₈): 0.54 equiv of THF coordinated.

Example 445

[2-(OH)-3,5-Br₂-C₆H₂]-C(Me)=NAr [Ar = 2,6-Me₂-C₆H₃]

The general procedure for imine synthesis was followed using 10.43 g (35.5 mmol) of 3',5'-dibromo-2'-hydroxyacetophenone and 5.59 g (1.30 equiv) of 2,6-dimethylaniline. A yellow powder (11.6 g) was isolated. The ¹H NMR spectrum of the initially

isolated product showed that it was contaminated by the hydroxyacetophenone. The product was repurified by washing with more methanol, dissolving in CH_2Cl_2 and drying over Na_2SO_4 , filtering and evaporating the solvent. A yellow powder (5.60 g) was isolated. The product mixture was now 12.7% of the starting aldehyde. The remainder is the desired imine product: ^1H NMR (CDCl_3) δ 7.78 (d, 1, Ar' : H), 7.71 (d, 1, Ar' : H), 7.11 (d, 2, Ar : H_m), 7.05 (t, 1, Ar : H_p), 2.18 (s, 3, $\text{N}=\text{CMe}$), 2.05 (s, 6, Ar : Me).

The sodium salt was synthesized according to the above general procedure and is clean and consistent with the desired product (no hydroxyacetophenone impurities present): ^1H NMR ($\text{THF}-d_8$): 0.81 equiv of THF coordinated.

Example 446

$[2-(\text{OH})-3,5-\text{Br}_2-\text{C}_6\text{H}_2]-\text{C}(\text{Me})=\text{NAr}$ [$\text{Ar} = 2-(t\text{-Bu})-\text{C}_6\text{H}_4$]

The general procedure for imine synthesis was followed using 10.04 g (34.2 mmol) of 3',5'-dibromo-2'-hydroxyacetophenone and 6.63 g (1.30 equiv) of 2-*t*-butylaniline. A yellow powder (12.63 g, 86.9%) was isolated: ^1H NMR (CDCl_3) δ 7.81 (d, 1, Ar' : H), 7.72 (d, 1, Ar' : H), 7.51 (d, 1, Ar : H), 7.27 (t, 1, Ar : H), 7.22 (t, 1, Ar : H), 6.51 (d, 1, Ar : H), 2.31 (s, 3, $\text{N}=\text{CMe}$), 1.37 (s, 9, CMe_3).

The sodium salt was synthesized according to the above general procedure: ^1H NMR ($\text{THF}-d_8$): trace THF coordinated.

Example 447

$[2-(\text{OH})-3,5-(t\text{-Bu})_2\text{C}_6\text{H}_2]-\text{CH}=\text{NAr}$ [$\text{Ar} = 2-(t\text{-Bu})-\text{C}_6\text{H}_4$]

The general procedure for imine synthesis was followed using 4.12 g (17.6 mmol) of 3,5-di-*t*-butyl-2-hydroxybenzaldehyde and 3.15 g (1.20 equiv) of 2-*t*-butylaniline. The desired imine product was isolated as a yellow powder: ^1H NMR (CDCl_3) δ 8.36 (s, 1, $\text{N}=\text{CH}$), 7.40 (d, 1, Ar' : H), 7.36 (d, 1, Ar : H), 7.18 (t, 1, Ar : H), 7.15 (d, 1, Ar' : H), 7.13 (t, 1, Ar : H),

6.80 (d, 1, Ar: H), 1.42, 1.37 and 1.26 (s, 9 each, CMe₃, C'Me₃, C''Me₃).

The sodium salt was synthesized according to the above general procedure: ¹H NMR (THF-d₈): ~1 equiv of THF coordinated.

Example 448

[2-(OH)-3,5-(t-Bu)₂C₆H₂]-CH=NAr [Ar = 2-Aza-C₅H₄]

The general procedure for imine synthesis was followed using 3.02 g (12.9 mmol) of 3,5-di-t-butyl-2-hydroxybenzaldehyde and 1.46 g (1.20 equiv) of 2-amino-pyridine. An orange powder (0.552 g, 13.8%) was isolated: ¹H NMR (CDCl₃) δ 9.47 (s, 1, N=CH), 8.51 (m, 1, Py: H), 7.77 (m, 1, Py: H), 7.48 (d, 1, Ar': H), 7.35 (d, 1, Ar': H), 7.33 (m, 1, Py: H), 7.20 (m, 1, Py: H), 1.48 (s, 9, CMe₃), 1.34 (s, 9, C'Me₃).

The sodium salt was synthesized according to the above general procedure: ¹H NMR (THF-d₈): 0.2 equiv of THF coordinated.

Example 449

[2-(OH)-3,5-(t-Bu)₂C₆H₂]-CH=NAr [Ar = 2-Aza-6-Me-C₅H₃]

The general procedure for imine synthesis was followed using 3.46 g (14.7 mmol) of 3,5-di-t-butyl-2-hydroxybenzaldehyde and 1.91 g (1.20 equiv) of 2-amino-3-picoline. The first crop isolated as a precipitate from methanol was an orange powder (1.18 g). This crop was not clean and was discarded, although some of the desired product was present as a minor component. The remaining methanol solution was allowed to slowly evaporate to give orange crystals. The methanol was decanted off of the crystals and the standard work-up procedure was followed. An orange powder (0.813 g) was isolated, and the NMR spectrum of this second crop was clean and consistent with the desired product: ¹H NMR (CDCl₃) δ 9.45 (s, 1, N=CH), 8.34 (d, 1, Py: H), 7.60 (d, 1, Py: H), 7.48 (d, 1, Ar': H), 7.38 (d, 1, Ar': H), 7.13 (dd, 1, Py: H), 2.49 (s, 3, Me), 1.5 (s, 9, CMe₃), 1.34 (s, 9, C'Me₃).

The sodium salt was synthesized according to the above general procedure: ^1H NMR ($\text{THF}-d_8$): 0.4 equiv of THF coordinated.

Example 450

5 $[2-(\text{OH})-3,5-(t\text{-Bu})_2\text{C}_6\text{H}_2]-\text{CH}=\text{NCHPh}_2$

The general procedure for imine synthesis was followed using 3.00 g (12.8 mmol) of 3,5-di-*t*-butyl-2-hydroxybenzaldehyde and 2.60 g (1.11 equiv) of aminodiphenylmethane. A yellow powder (2.85 g, 55.7%) was isolated: ^1H NMR (CDCl_3) δ 8.50 (s, 1, $\text{N}=\text{CH}$), 7.42 (d, 1, Ar' : H), 7.40 - 7.23 (m, 10, CPh_2), 7.11 (d, 1, Ar' : H), 5.63 (s, 1, CHPh_2), 1.48 and 1.32 (s, 9 each, CMe_3 and $\text{C}'\text{Me}_3$).

10 The sodium salt was synthesized according to the above general procedure: ^1H NMR ($\text{THF}-d_8$): 1 equiv of THF coordinated.

Example 451

$[2-(\text{OH})-3,5-(t\text{-Bu})_2\text{C}_6\text{H}_2]-\text{CH}=\text{NR}$ [$\text{R} = 1,2,3,4\text{-tetrahydro-1-naphthyl}$]

20 The general procedure for imine synthesis was followed using 3.08 g (13.1 mmol) of 3,5-di-*t*-butyl-2-hydroxybenzaldehyde and 2.32 g (1.20 equiv) of 1,2,3,4-tetrahydro-1-naphthylamine. A yellow powder (3.97 g, 83.4%) was isolated: ^1H NMR (CDCl_3) δ 8.45 (s, 1, $\text{N}=\text{CH}$), 7.39 (d, 1, Ar' : H), 7.22 - 7.04 (m, 5, Ar : H, Ar' : H), 4.53 (m, 1, $\text{NCHCH}_2\text{CH}_2\text{CH}_2$), 2.88 (m, 2, $\text{NCHCH}_2\text{CH}_2\text{CH}_2$), 2.14 - 1.79 (m, 4, $\text{NCHCH}_2\text{CH}_2\text{CH}_2$), 1.42 (s, 9, CMe_3), 1.32 (s, 9, $\text{C}'\text{Me}_3$).

25 The sodium salt was synthesized according to the above general procedure: ^1H NMR ($\text{THF}-d_8$): 0.6 equiv of THF coordinated.

Example 452

$[2-(\text{OH})-3,5-(\text{NO}_2)_2\text{C}_6\text{H}_2]-\text{CH}=\text{NAr}$ [$\text{Ar} = 2-(t\text{-Bu})-\text{C}_6\text{H}_4$]

30 The general procedure for imine synthesis was followed using 3.05 g (14.4 mmol) of 3,5-dinitrosalicylaldehyde and 2.57 g (1.20 equiv) of 2-*t*-butylaniline. A yellow powder was isolated: ^1H NMR (CDCl_3) δ 8.94 (s, 1, $\text{N}=\text{CH}$), 8.54 (d, 1, Ar' : H), 8.50

(d, 1, Ar': H), 7.49 (d, 1, Ar: H), 7.35 (t, 1, Ar: H), 7.31 (t, 1, Ar: H), 7.02 (d, 1, Ar: H), 1.40 (s, 9 CMe₃).

The sodium salt was synthesized according to the above general procedure: ¹H NMR (THF-d₈): 0.79 equiv of THF coordinated.

Example 453

[2-(OH)-3,5-(NO₂)₂C₆H₂]-CH=NAr [Ar = 2-Me-6-Cl-C₆H₃]

The general procedure for imine synthesis was followed using 1.56 g (7.33 mmol) of 3,5-dinitrosalicylaldehyde and 1.25 g (1.20 equiv) of 2-chloro-6-methylaniline. An orange powder (1.35 g, 55.0%) was isolated: ¹H NMR (CDCl₃) δ 15.96 (br s, 1, OH), 8.71 (s, 1, N=CH), 8.60 (d, 1, H_{aryl}), 7.50 - 7.15 (m, 4, H_{aryl}), 2.36 (s, 1, Me).

The sodium salt was synthesized according to the above general procedure: ¹H NMR (THF-d₈): 0.14 equiv of THF coordinated.

Example 454

[2-(OH)-3,5-(NO₂)₂C₆H₂]-CH=NR [R = 1,2,3,4-tetrahydro-1-naphthyl]

The general procedure for imine synthesis was followed using 3.07 g (14.5 mmol) of 3,5-dinitrosalicylaldehyde and 2.55 g (1.20 equiv) of 1,2,3,4-tetrahydro-1-naphthylamine. A yellow powder (4.31 g, 87.1%) was isolated: ¹H NMR (CDCl₃) δ 8.98 (d, 1, Ar': H), 8.36 (d, 1, Ar': H), 8.07 (d, 1, Ar: H), 7.36 (m, 1, Ar: H), 7.27 (m, 3, N=CH and Ar: H), 7.15 (d, 1, Ar: H), 5.04 (m, 1, NCHCH₂CH₂CH₂), 2.90 (m, 2, NCHCH₂CH₂CH₂), 2.26, 1.97 and 1.87 (m's, 2, 1 and 1 each, NCHCH₂CH₂CH₂).

The sodium salt was synthesized according to the above general procedure: ¹H NMR (THF-d₈): 0.11 equiv of THF coordinated.

Example 455

[2-(OH)-3,5-I₂-C₆H₂]-CH=NAr [Ar = 2,6-(i-Pr)₂-C₆H₃]

The general procedure for imine synthesis was followed using 6.00 g (16.0 mmol) of 3,5-

diiodosalicylaldehyde and 3.70 g (1.31 equiv) of 2,6-diisopropylaniline. A yellow powder (7.93 g, 93.0%) was isolated: ^1H NMR (CDCl_3) δ 8.14 (d, 1, Ar': H), 8.10 (s, 1, N=CH), 7.60 (d, 1, Ar': H), 7.20 (m, 3, Ar: H), 2.92 (septet, 2, CHMe₂), 1.18 (d, 12, CHMe₂).

The sodium salt was synthesized according to the above general procedure: ^1H NMR ($\text{THF}-d_8$): 0.67 equiv of THF coordinated.

Example 456

10 [2-(OH)-4,6-(OMe)₂-C₆H₂]-CH=NAr [Ar = 2,6-(i-Pr)₂-C₆H₃]

The general procedure for imine synthesis was followed using 5.05 g (27.7 mmol) of 4,6-dimethoxysalicylaldehyde and 5.90 g (1.20 equiv) of 2,6-diisopropylaniline. A yellow powder (3.59 g, 38.0%) was isolated: ^1H NMR (CDCl_3) δ 8.58 (s, 1, N=CH), 7.18 (s, 3, Ar: H), 6.13 (d, 1, Ar': H), 5.92 (d, 1, Ar': H), 3.84 (s, 3, OMe), 3.80 (s, 3, OMe'), 3.03 (septet, 1, CHMe₂), 1.19 (d, 12, CHMe₂).

The sodium salt was synthesized according to the above general procedure: ^1H NMR ($\text{THF}-d_8$): No THF coordinated.

Example 457

[2-Hydroxynaphthyl]-CH=NAr [Ar = 2,6-Br₂-4-F-C₆H₂]

25 The general procedure for imine synthesis was followed using 29.8 g (173 mmol) of 2-hydroxy-1-naphthaldehyde and 52.0 g (193 mmol) of 2,6-dibromo-4-fluoroaniline. A yellow powder (62.1 g, 84.9%, 2 crops) was isolated: ^1H NMR (CDCl_3) δ 9.40 (s, 1, N=CH), 8.09 (d, 1, Ar': H), 7.92 (d, 1, Ar': H), 7.81 (d, 1, Ar': H), 7.55 (t, 1, Ar': H), 7.43 (d, 2, Ar: H), 7.40 (t, 1, Ar': H), 7.25 (d, 1, Ar': H).

The sodium salt was synthesized according to the above general procedure: ^1H NMR ($\text{THF}-d_8$): 0.66 equiv of THF coordinated.

Example 458

35 [2-Hydroxynaphthyl]-CH=NAr [Ar = 2-Aza-6-Me-C₅H₃]

The general procedure for imine synthesis was followed using 3.44 g (20.0 mmol) of 2-hydroxy-1-

naphthaldehyde and 2.59 g (1.20 equiv) of 2-amino-3-picoline. A yellow-orange powder (4.51 g, 86.0%) was isolated: ^1H NMR (CDCl_3) δ 9.94 (d, 1, H_{aryl}), 8.27 (d, 1, $\text{N}=\text{CH}$), 8.09 (d, 1, H_{aryl}), 7.68 (d, 1, H_{aryl}), 7.54 (d, 1, H_{aryl}), 7.51 (d, 1, H_{aryl}), 7.44 (t, 1, H_{aryl}), 7.24 (t, 1, H_{aryl}), 7.02 (t, 1, H_{aryl}), 6.85 (d, 1, H_{aryl}), 2.44 (s, 3, Me).

The sodium salt was synthesized according to the above general procedure: ^1H NMR ($\text{THF}-d_8$): 0.1 equiv of THF coordinated.

Example 459

[2-Hydroxynaphthyl]-CH=NAr [Ar = 2-(t-Bu)-C₆H₄]

The general procedure for imine synthesis was followed using 10.19 g (59.2 mmol) of 2-hydroxy-1-naphthaldehyde and 10.60 g (1.20 equiv) of 2-t-butylaniline. A yellow powder (10.8 g, 60.4%) was isolated: ^1H NMR (CDCl_3) δ 9.27 (d, 1, $\text{N}=\text{CH}$), 8.18 (d, 1, H_{aryl}), 7.88 (d, 1, H_{aryl}), 7.79 (d, 1, H_{aryl}), 7.55 (t, 1, H_{aryl}), 7.52 (d, 1, H_{aryl}), 7.39 (t, 1, H_{aryl}), 7.37 (t, 1, H_{aryl}), 7.30 (t, 1, H_{aryl}), 7.21 (d, 1, H_{aryl}), 7.19 (d, 1, H_{aryl}), 1.52 (s, 9, CMe_3).

The sodium salt was synthesized according to the above general procedure: ^1H NMR ($\text{THF}-d_8$): 0.48 equiv of THF coordinated.

25

Example 460

(Ar) (H)N-C(Me)=CH-C(O)-Ph [Ar = 2,6-(i-Pr)₂-C₆H₃]

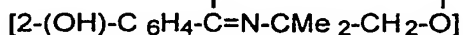
The general procedure for imine synthesis was followed using 5.17 g (31.9 mmol) of 1-benzoylacetone and 7.35 g (1.30 equiv) of 2,6-diisopropylaniline. After 2 days, no precipitate formed from the methanol solution. However, slow evaporation of the methanol yielded single crystals, which were isolated and washed with a small amount of additional methanol. The standard work-up procedure was then followed to yield a white powder (2.56 g, 25.0%): ^1H NMR (CDCl_3) δ 7.89 (d, 2, H_{aryl}), 7.38 (m, 3, H_{aryl}), 7.25 (t, 1, H_{aryl}), 7.12 (d, 1, H_{aryl}), 5.86 (s, 1, $=\text{CH}$), 3.02 (septet, 2, CHMe_2), 1.71 (s, 3, N-C(Me)), 1.17 and 1.11 (d, 6 each,

CHMeMe'); ^{13}C NMR (CDCl_3) δ 188.4 (C(O)), 165.0 (N-C(Me)), 146.2 (Ar: C_o), 140.0 and 133.5 (Ph: C_{ipso}; Ar: C_{ipso}), 130.8 and 128.3 (Ar: C_p; Ph: C_p), 128.1, 127.1 and 123.5 (Ph: C_o, C_m; Ar: C_m), 92.1 (C(Me)=CH), 28.5 (CHMe₂), 24.6 and 22.7 (CHMeMe'), 19.7 (N-C(Me)).

The sodium salt was synthesized according to the above general procedure: ^1H NMR (THF-*d*₈): 0.66 equiv of THF coordinated.

Example 461

10

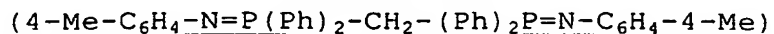


A 200 mL sidearm flask was charged with 5.0 g (42 mmol, 1.0 equiv) of 2-hydroxybenzonitrile, 5.6 g (63 mmol, 1.5 equiv) of 2-amino-2-methylpropanol, 0.29 g (2.1 mmol, 0.05 equiv) of ZnCl_2 , and 90 mL of chlorobenzene. The reaction mixture was heated to reflux under N_2 atmosphere for 24 h. After this time, reflux was discontinued, the flask was cooled to ambient temperature, and most of the volatile materials were removed using a rotary evaporator. The resulting residue was dissolved in ~100 mL of CH_2Cl_2 , transferred to a separatory funnel, and washed with 3 x 50 mL of H_2O . The combined H_2O washings were back extracted with ~30 mL of CH_2Cl_2 , and the combined CH_2Cl_2 extracts were then dried over Na_2SO_4 , filtered and evaporated to yield a brown oil which was purified by flash chromatography (SiO_2 , eluting with 5:1 hexanes:EtOAc), to yield 6.3 g (78%) of the desired product: ^1H NMR (CDCl_3) δ 12.2 (br s, 1, OH), 7.6 (m, 1, H_{aryl}), 7.4 (m, 1, H_{aryl}), 7.06 (m, 1, H_{aryl}), 6.92 (m, 1, H_{aryl}), 4.14 (s, 2, CH₂), 1.44 (s, 6, CMe₂).

The sodium salt was synthesized according to the above general procedure: ^1H NMR (THF-*d*₈): 0.20 equiv of THF coordinated.

Example 462

35

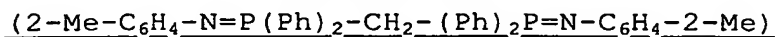


See *Phosphorus, Sulfur, and Silicon* **1990**, 47, 401. A 100-mL 3-neck round-bottomed flask was fitted with a condenser, a nitrogen inlet and an addition funnel. It

was charged with 2.64 g (6.87 mmol) of bis(diphenylphosphino)methane (DPPM) dissolved in 17 mL of benzene. The addition funnel was charged with 1.86 g (14.0 mmol) of 4-Me-C₆H₄-N₃ (prepared from *p*-toluidine hydrochloride, sodium nitrite and sodium azide, see Ugi, I; Perlinger, H.; Behringer, L. *Chemische Berichte* 1958, 91, 2330) dissolved in ca. 7-10 mL of benzene. The DPPM solution was heated to 60°C and the aryl azide solution slowly added to the reaction mixture. As the addition occurred, nitrogen was evolved. After the addition was completed, the reaction mixture was kept an additional 4 h at 60 °C. The solvent was then removed in vacuo, and the solid was collected, washed with 2 x 15mL of hexane and dried in vacuo. The yield was 3.75 g (92%): ¹H NMR (CDCl₃) δ 7.72 (m, 8, PPh₂: H_o), 7.41 (t, 4, PPh₂: H_p), 7.29 (t, 3, PPh₂: H_m), 6.83 (d, 4, NAr: H_m), 6.52 (d, 4, NAr: H_o), 3.68 (t, 2, J_{HP} = 14.2, PCH₂P), 2.21 (s, 6, NAr: Me).

The sodium salt was synthesized according to the above general procedure: ¹H NMR (THF-*d*₈): 0.39 equiv of THF coordinated.

Example 463



A 100-mL 3-neck round-bottomed flask was fitted with a condenser, a nitrogen inlet and an addition funnel. It was charged with 3.0 g (7.80 mmol) of bis(diphenylphosphino)methane (DPPM) dissolved in 20 mL of toluene. The addition funnel was charged with 2.11 g (15.8 mmol) of 2-Me-C₆H₄-N₃ (prepared from *o*-toluidine hydrochloride, sodium nitrite and sodium azide) dissolved in ca. 12 mL of toluene. The DPPM solution was heated to 60°C and the aryl azide solution slowly added to the reaction mixture. As the addition occurred, nitrogen was evolved. After the addition was completed, the reaction mixture was kept an additional 4 h at 60°C. The solvent was then removed in vacuo, the solid was collected and recrystallized from Et₂O/hexane. The yield was 2.70 g (58%). ¹H NMR

(CDCl₃) δ 7.68 (m, 8, PPh₂: H_o), 7.38 (t, 4, PPh₂: H_p), 7.25 (t, 8, PPh₂: H_m), 7.09 (d, 2, NAr: H_m'), 6.76 (t, 2, NAr: H_m), 6.23 (t, 2, NAr: H_p), 6.23 (d, 2, NAr: H_o), 3.87 (t, 2, J_{HP} = 13.5, PCH₂P), 2.29 (s, 6, NAr: Me).

5 The sodium salt was synthesized according to the above general procedure: ¹H NMR (THF-*d*₈): 0.59 equiv of THF coordinated.

Example 464

Lithium 5-Methyl-2-Thiophenecarboxylate

10 The sodium salt was synthesized from commercially available 5-methyl-2-thiophenecarboxylic acid according to the above general procedure and the cation was exchanged with an excess of lithium chloride to improve product solubility: ¹H NMR (THF-*d*₈): 0.25 equiv of
15 THF coordinated.

Example 465

Cy₂PCH₂CH(CH₃)SLi

A 100-mL Schlenk flask was charged with 1.28 g (6.28 mmol) of PCy₂Li (prepared from PCy₂H and *n*-BuLi)
20 dissolved in 20 mL of THF. The flask was cooled to -78°C and propylene sulfide (520 mg, 7.01 mmol) was vacuum transferred onto the lithium salt solution. The reaction mixture was kept at -78°C for 45 min. The dry ice/acetone bath was then removed and the yellowish
25 solution was allowed to warm to ambient temperature. After an additional 20 min, the solvent was removed in vacuo. The solid was washed three times with 30 mL of hexane and dried in vacuo. The yield was 1.37 g (78%).
¹H NMR (THF-*d*₈, 300 MHz, 23°C) δ 2.80 (m, 1, CH), 1.31
30 (d, 3, J = 6 Hz, CH₃), 1-2 (m, 24, Cy₂, PCH₂); ³¹P NMR: δ -7.6.

Example 466

Sodium 2,3,5,6-Tetrachloro-4-Pyridinethiolate

35 The sodium salt was synthesized according to the above general procedure from the commercially available 2,3,5,6-tetrachloro-4-pyridinethiol.

Example 467Sodium 2,5-Dimethylpyrrole

The sodium salt was synthesized according to the above general procedure from the commercially available 2,5-dimethylpyrrole: ^1H NMR ($\text{THF}-d_8$): No THF coordinated.

Example 468Sodium 2,6-Dibromo-4-Methylanilide

The sodium salt was synthesized according to the above general procedure from the commercially available 2,6-dibromo-4-methylaniline: ^1H NMR ($\text{THF}-d_8$): 0.5 equiv THF coordinated.

Examples 469-498

Complexes 21 through 49 were synthesized according to the general procedure for the synthesis of allyl initiators (see above under Examples 17-40).

Example 469

Complex 21a. Two equiv (2.77 g, 6.45 mmol) of the sodium salt of the ligand were reacted with one equiv (1.53 g, 3.22 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 2.94 g (87.4% yield) of a yellow powder: ^1H NMR (C_6D_6) δ 7.39 (d, 1, Ar' : H), 7.29 (d, 1, Ar' : H), 7.0 - 6.9 (m, 3, Ar: H), 4.00 (m, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 3.57 and 2.86 (septet, 1 each, CHMe_2 and $\text{C}'\text{HMe}_2$), 3.25 (s, 3, OMe), 2.86 (s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 1.92 (m, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 1.47 (s, 3, $\text{N}=\text{CMe}$), 1.34, 1.18, 0.89 and 0.79 (d, 3 each, CHMeMe' and $\text{C}'\text{HMeMe}'$), 1.12 (s, 1 each, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$).

Example 470

Complex 21b. Two equiv (720 mg, 1.68 mmol) of the sodium salt of the ligand were reacted with one equiv (225 mg, 0.834 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = H_2CCHCH_2) to give 599 mg (77.6% yield) of a yellow powder: ^1H NMR (CDCl_3) δ 7.39 (d, 1, Ar' : H), 7.35 (d, 1, Ar' : H), 7.13 - 7.00 (m, 3, Ar: H), 5.78 (m, 1, $\text{H}_2\text{CCHC}'\text{H}_2$), 3.66 and 3.07 (m, 1 each, CHMe_2 and $\text{C}'\text{HMe}_2$), 3.21, 2.64, 1.44 and 1.11 (d, 1 each, $\text{HH}'\text{CCHC}'\text{HH}'$),

1.99 (s, 3, N=CMe), 1.31, 1.26, 1.07 and 0.99 (d, 3 each, CHMeMe' and C'HMeMe'); ¹³C NMR (CDCl₃) δ 168.7 (N=CMe), 159.5, 150.0, 137.7, 137.0, 131.8, 128.7, 127.9, 125.9, 123.8, 123.3, 120.9, 117.1, 113.1 (Ar: C_o, C_o', C_m, C_m', C_p, Ar': C_o, C_o', C_m, C_m', C_p, H₂CCHCH₂), 59.4 and 52.8 (H₂CCHC'H₂), 28.3 and 27.8 (CHMe₂, C'HMe₂), 24.1, 23.64, 23.54 and 23.4 (CHMeMe' and C'HMeMe'), 20.3 (N=CMe).

Example 471

Complex **22a**. Two equiv (809 mg, 2.14 mmol) of the sodium salt of the ligand were reacted with one equiv (508 mg, 1.07 mmol) of [(allyl)Ni(μ-Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 792 mg (79.6% yield) of a yellow powder: ¹H NMR (C₆D₆) δ 7.57 (d, 1, Ar': H), 7.30 (d, 1, Ar': H), 7.0 - 6.9 (m, 3, Ar: H), 4.10 (m, 1, HH'CC(CO₂Me)C'HH'), 3.38 (s, 3, OMe), 2.69 (s, 1, HH'CC(CO₂Me)C'HH'), 2.02 and 2.12 (s, 3, Ar: Me, Me'), 1.89 (m, 1, HH'CC(CO₂Me)C'HH'), 1.45 (s, 3, N=CMe), 1.35 (s, 1, HH'CC(CO₂Me)C'HH').

Example 472

Complex **23a**. Two equiv (1.56 g, 4.20 mmol) of the sodium salt of the ligand were reacted with one equiv (1.00 g, 2.10 mmol) of [(allyl)Ni(μ-Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 1.35 g (65.3% yield) of a yellow powder: According to the ¹H NMR spectrum, two isomers (*t*-Bu group positioned syn and anti to the CO₂Me group) are present in a 1:1 ratio. ¹H NMR (C₆D₆) δ 7.6 - 6.5 (m, 8, H_{aryl}), 4.16 and 4.01 (s, 1 each, HH'CC(CO₂Me)C'HH' of each isomer), 3.42 and 3.42 (s, 3 each, OMe of each isomer), 2.82 and 2.74 (s, 1 each, HH'CC(CO₂Me)C'HH' of each isomer), 2.22 and 2.02 (s, 1 each, HH'CC(CO₂Me)C'HH' of each isomer), 1.63 and 1.56 (s, 3 each, N=CMe of each isomer), 1.56 and 1.38 (s, 9 each, CMe₃ of each isomer), 1.54 and 1.36 (s, 1 each, HH'CC(CO₂Me)C'HH' of each isomer).

Example 473

Complex **24a**. Two equiv (1.10 g, 2.15 mmol) of the sodium salt of the ligand were reacted with one equiv

(512 mg, 1.08 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 635 mg (49.5% yield) of a yellow powder: ^1H NMR (CDCl_3) δ 7.72 (s, 1, $\text{N}=\text{CH}$), 7.70 (d, 1, $\text{Ar}'\text{: H}$), 7.20 - 7.08 (m, 4, $\text{Ar}\text{: H}$, $\text{Ar}'\text{: H}$), 3.90 (d, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 3.80 (s, 3, OMe), 3.73 and 2.92 (septet, 1 each, CHMe_2 and $\text{C}'\text{HMe}_2$), 2.99 (s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 2.03 (m, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 1.56 (s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 1.30, 1.22, 1.08 and 0.93 (d, 3 each, CHMeMe' and $\text{C}'\text{HMeMe}'$).

10

Example 474

Complex **25a**. Two equiv (3.25 g, 6.31 mmol) of the sodium salt of the ligand were reacted with one equiv (1.50 g, 3.16 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 3.49 g (90.6% yield) of a yellow powder: ^1H NMR spectrum is clean and consistent with the desired product.

Example 475

Complex **26a**. Two equiv (2.01 g, 4.20 mmol) of the sodium salt of the ligand were reacted with one equiv (1.00 g, 2.10 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 1.51 g (64.9% yield) of a golden brown powder: ^1H NMR (C_6D_6) δ 7.64 (s, 1, $\text{Ar}'\text{: H}$), 7.25 (s, 1, $\text{Ar}'\text{: H}$), 6.70 (, 3, $\text{Ar}\text{: H}$), 3.85 (s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 3.15 (s, 3, OMe), 2.44 (s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 1.97 and 1.85 (s, 3 each, $\text{Ar}\text{: Me}$, Me'), 1.60 (s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 1.20 (s, 3, $\text{N}=\text{CMe}$), 1.11 (s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$); ^{13}C NMR (C_6D_6 , selected resonances) δ 59.5, 52.7, and 51.3 ($\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{H}_2$), 19.0, 18.6, and 18.0 ($\text{N}=\text{CMe}$, $\text{Ar}\text{: Me}$, Me').

30

Example 476

Complex **27a**. Two equiv (951 mg, 2.13 mmol) of the sodium salt of the ligand were reacted with one equiv (505 mg, 1.06 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 851 mg (68.6% yield) of a yellow powder: ^1H NMR spectrum in C_6D_6 is clean and consistent with the desired product. The product exists as a 1:1

35

ratio of isomers (*t*-Bu group positioned syn or anti to the CO₂Me group.)

Example 477

Complex **28a**. Two equiv (983 mg, 2.14 mmol) of the sodium salt of the ligand were reacted with one equiv (509 mg, 1.07 mmol) of [(allyl)Ni(μ -Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 1.02 g (90.9% yield) of a green powder: ¹H NMR spectrum in C₆D₆ is broad, but consistent with the desired product. The product exists as an ~1:1 ratio of isomers (*t*-Bu group positioned syn or anti to the CO₂Me group.)

Example 478

Complex **29a**. Two equiv (550 mg, 1.59 mmol) of the sodium salt of the ligand were reacted with one equiv (308 mg, 0.647 mmol) of [(allyl)Ni(μ -Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 478 mg (64.3% yield) of a dark brown powder.

Example 479

Complex **30a**. Two equiv (478 mg, 1.27 mmol) of the sodium salt of the ligand were reacted with one equiv (303 mg, 0.637 mmol) of [(allyl)Ni(μ -Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 375 mg (61.4% yield) of a dark brown powder:

Example 480

Complex **31a**. Two equiv (1.04 g, 2.10 mmol) of the sodium salt of the ligand were reacted with one equiv (500 mg, 1.05 mmol) of [(allyl)Ni(μ -Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 948 mg (81.1% yield) of a green-yellow powder: ¹H NMR (THF-*d*₈) δ 7.85, 7.34, 7.14, 7.12, 6.63 and 6.43 (N=CH, H_{aryl}, CHPh₂), 3.72 (s, 3, OMe), 3.80, 2.78, 2.78, and 1.48 (s, 1 each, HH'CC(CO₂Me)C'HH'), 1.37 and 1.18 (CMe₃, C'Me₃); ¹³C NMR (THF-*d*₈) δ 166.9 (N=CH), 167.1, 166.9, 164.1, 142.3, 142.0, 140.9, 135.8, 130.3, 130.0, 129.4, 129.3, 129.27, 128.3, 118.3, 110.4 (C_{aryl} and H₂CC(CO₂Me)CH₂), 81.0 (CHPh₂), 59.1 and 45.8 (H₂CC(CO₂Me)CH₂), 52.6 (OMe), 35.9 and 34.3 (CMe₃, C'Me₃), 31.7 and 29.7 (CMe₃, C'Me₃).

Example 481

Complex **32a**. Two equiv (923 mg, 2.15 mmol) of the sodium salt of the ligand were reacted with one equiv (512 mg, 1.08 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 907 mg (81.1% yield) of a brown-orange powder.

Example 482

Complex **33a**. Two equiv (891 mg, 2.11 mmol) of the sodium salt of the ligand were reacted with one equiv (502 mg, 1.06 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 940 mg (89.1% yield) of a gold powder. Two major isomers are present in a 1.18:1 ratio. There is a very small amount of a third product or isomer present. The ^1H NMR assignments of the two major isomers follow: ^1H NMR (CDCl_3) δ 8.30 and 8.25 (d, 1 each, Ar': H of each isomer), 7.48 and 7.32 (d, 1 each, Ar': H of each isomer), 6.94 and 6.78 (s, 1 each, $\text{N}=\text{CH}$ of each isomer), 7.05 (m, 2, H_{aryl}), 6.83 (m, 1, H_{aryl}), 6.80 (m, 3, H_{aryl}), 6.58 (d, 1, H_{aryl}), 6.45 (m, 1, H_{aryl}), 3.90 and 3.73 (m, 1 each, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$ of each isomer), 3.18 and 3.09 (s, 3 each, OMe of each isomer), 2.43 and 2.41 (s, 1 each, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$ of each isomer), 2.26 and 2.08 (m, 1 each, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$ of each isomer), 1.30 and 1.17 (s, 1 each, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$ of each isomer), 1.18 and 1.03 (s, 9 each, CMe_3 of each isomer).

Example 483

Complex **34a**. Two equiv (719 mg, 1.95 mmol) of the sodium salt of the ligand were reacted with one equiv (464 mg, 0.977 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 928 mg (96.6% yield) of a yellow powder. The ^1H NMR spectrum indicates that two isomers (Cl group positioned syn and anti to the CO_2Me group) are present in a 2.5 to 1 ratio. Major Isomer: ^1H NMR (C_6D_6) δ 8.50 (d, 1, Ar': H), 7.52 (d, 1, Ar': H), 7.10 (d, 1, Ar: H), 6.75 (t, 1, Ar: H), 6.72 (s, 1, $\text{N}=\text{CH}$), 6.70 (d, 1, Ar: H), 4.02 (d, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 3.28 (s, 3, OMe), 2.60 (s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 2.18

(d, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 1.99 (s, 3, Ar: Me), 1.63 (s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$); Minor Isomer: ^1H NMR (C_6D_6) δ 8.50 (d, 1, Ar': H), 7.53 (d, 1, Ar': H), 7.06 (d, 1, Ar: H), 6.8 - 6.7 (m, 3, $\text{N}=\text{CH}$, Ar: H), 4.10 (d, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 3.39 (s, 3, OMe), 2.57 (s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 2.19 (d, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 1.98 (s, 3, Ar: Me), 1.35 (s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$).

Example 484

Complex **35a**. Two equiv (765 mg, 2.11 mmol) of the sodium salt of the ligand were reacted with one equiv (500 mg, 1.05 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 890 mg (84.7% yield) of a red powder.

Example 485

Complex **36a**. Two equiv (1.22 g, 2.10 mmol) of the sodium salt of the ligand were reacted with one equiv (500 mg, 1.05 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 1.18 g (81.7% yield) of a yellow powder: ^1H NMR (CD_2Cl_2) δ 8.03 (d, 1, Ar': H), 7.70 (s, 1, $\text{N}=\text{CH}$), 7.36 (d, 1, Ar': H), 7.20 - 7.07 (m, 3, Ar: H), 3.88 (m, 1, $\text{HH}'\text{C}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 3.78 (s, 3, OMe), 3.71 (septet, 1, CHMe_2), 2.97 (s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 2.90 (septet, 1, $\text{C}'\text{HMe}_2$), 1.96 (m, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 1.57 (s, 1 $\text{HH}''\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 1.28, 1.20, 1.04 and 0.90 (d, 3 each, CHMeMe' , $\text{C}'\text{HMeMe}'$); ^{13}C NMR (CD_2Cl_2) δ 166.8 ($\text{N}=\text{CH}$), 167.9, 164.6, 153.2, 151.6, 144.4, 141.4, 140.6, 128.4, 125.3, 125.2, 121.1, 114.2, 98.2 and 75.2 (Ar: C_o , C_o' , C_m , C_m' , C_p ; Ar': C_o , C_o' , C_m , C_m' , C_p ; $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{H}_2$), 62.7, 54.5 and 50.2 ($\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{H}_2$), 30.2 and 29.8 (CHMe_2 , $\text{C}'\text{HMe}_2$), 26.7, 26.5, 24.2 and 23.7 (CHMeMe' , $\text{C}'\text{HMeMe}'$).

Example 486

Complex **37a**. Two equiv (771 mg, 2.12 mmol) of the sodium salt of the ligand were reacted with one equiv (504 mg, 1.06 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 992 mg (93.9% yield) of a green powder: ^1H NMR (CD_2Cl_2) δ 8.25 (s, 1, $\text{N}=\text{CH}$), 7.18 (m,

3, Ar: H), 6.02 (d, 2, Ar': H), 5.68 (d, 2, Ar': H),
3.90 (septet, 1, CHMe₂), 3.84, 3.78 and 3.71 (s, 3
each, Ar: OMe and OMe'; CO₂Me), 3.65 (s, 1,
HH'CC(CO₂Me)C'HH'), 3.03 (septet, 1, C' HMe₂), 2.80 (s,
5 1, HH'CC(CO₂Me)C'HH'), 1.88 (s, 1, HH'CC(CO₂Me)C'HH'),
1.46 (s, 1, HH'CC(CO₂Me)C'HH'), 1.36, 1.28, 1.14 and
0.99 (d, 3 each, CHMeMe', C' HMeMe').

Example 487

Complex **38a**. Two equiv (1.04 g, 2.12 mmol) of the
10 sodium salt of the ligand were reacted with one equiv
(503 mg, 1.06 mmol) of [(allyl)Ni(μ-Br)]₂ (allyl =
H₂CC(CO₂Me)CH₂) to give 1.10 g (89.3% yield) of a green-
yellow powder: ¹H NMR (CD₂Cl₂) δ 8.65 (s, 1, N=CH),
7.84 (d, 1, Ar': H), 7.77 (d, 1, Ar': H), 7.68 (t, 1,
15 Ar': H), 7.48 (m, 2, Ar: H), 7.44 (t, 1, Ar': H), 7.27
(t, 1, Ar': H), 7.07 (d, 1, Ar': H), 3.86 (s, 3, OMe),
3.80, 2.84, 2.05 and 1.91 (s, 1 each,
HH'CC(CO₂Me)C'HH').

Example 488

20 Complex **39a**. Two equiv (614 mg, 2.10 mmol) of the
sodium salt of the ligand were reacted with one equiv
(500 mg, 1.05 mmol) of [(allyl)Ni(μ-Br)]₂ (allyl =
H₂CC(CO₂Me)CH₂) to give 683 mg (77.6% yield) of a green-
yellow powder: ¹H NMR (C₆D₆) δ 9.17 (s, 1, N=CH), 8.39
25 (d, 1, H_{aryl}), 7.62 (d, 1, H_{aryl}), 7.52 (d, 1, H_{aryl}), 7.52
(d, 1, H_{aryl}), 7.44 (d, 1, H_{aryl}), 7.24 (t, 1, H_{aryl}), 7.18
(t, 1, H_{aryl}), 7.11 (d, 1, H_{aryl}), 6.75 (dd, 1, H_{aryl}),
4.19 (br s, 1, HH'CC(CO₂Me)C'HH'), 3.43 (s, 3, OMe),
2.67 (br s, 1, HH'CC(CO₂Me)C'HH'), 2.32 (br s, 1,
30 HH'CC(CO₂Me)C'HH'), 2.24 (s, 3, Ar: Me), 1.65 (s, 1,
HH'CC(CO₂Me)C'HH').

Example 489

Compound **40a**. Two equiv (765 mg, 2.12 mmol) of
the sodium salt of the ligand were reacted with one
35 equiv (505 mg, 1.06 mmol) of [(allyl)Ni(μ-Br)]₂ (allyl
= H₂CC(CO₂Me)CH₂) to give 925 mg (95.1% yield) of a
green powder: Three isomers or products are present
in a 1.35 to 1.02 to 1.00 ratio. ¹H NMR (CDCl₃,

selected resonances only) δ 8.84, 8.72 and 8.20 (N=CH of the 3 products), 3.29 (OMe of the 3 products--all overlapping), 1.81, 1.45 and 1.25 (CMe₃ of the 3 products).

5

Example 490

Complex **41a**. Two equiv (867 mg, 2.22 mmol) of the sodium salt of the ligand were reacted with one equiv (527 mg, 1.11 mmol) of [(allyl)Ni(μ -Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 782 mg (77.1% yield) of a golden brown powder: ¹H NMR (C₆D₆) δ 8.08 (d, 2, Ph: C_o), 7.27 (m, 6, Ph: C_m, C_p; Ar: C_m, C_p), 6.01 (s, 1, PhCCHCMe), 4.23 (s, 1, HH'CC(CO₂Me)C'HH'), 4.03 (septet, 1, CHMe₂), 3.45 (s, 3, OMe), 3.33 (septet, 1, C' HMe₂), 3.04 (s, 1, HH'CC(CO₂Me)C'HH'), 2.18 (s, 1, HH'CC(CO₂Me)CHH'), 1.69 (s, 3, CMeNAr), 1.38 (s, 1, HH'CC(CO₂Me)CHH'), 1.54, 1.41, 1.29 and 1.18 (d, 3 each, CHMeMe' and C' HMeMe').

10

15

Example 491

Complex **42a**. Two equiv (495 mg, 2.17 mmol) of the sodium salt of the ligand were reacted with one equiv (516 mg, 1.09 mmol) of [(allyl)Ni(μ -Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 434 mg (57.4% yield) of a yellow powder: ¹H NMR (C₆D₆) δ 7.82 (d, 1, H_{aryl}), 7.20 (d, 1, H_{aryl}), 7.10 (t, 1, H_{aryl}), 6.47 (t, 1, H_{aryl}), 4.10 (s, 1, HH'CC(CO₂Me)C'HH'), 3.27 (s, 3, OMe), 3.27 (s, 2, OCH₂, overlaps with OMe), 3.02, 2.73 and 1.11 (s, 1 each, HH'CC(CO₂Me)C'HH'), 0.81 and 0.73 (s, 3 each, CMeMe').

25

Example 492

Complex **43a**. Two equiv (586 mg, 0.909 mmol) of the sodium salt of the ligand were reacted with one equiv (216 mg, 0.455 mmol) of [(allyl)Ni(μ -Br)]₂ (allyl = H₂CC(CO₂Me)CH₂) to give 506 mg (74.1% yield) of a dark red powder: ¹H NMR (THF-*d*₈) δ 7.50 (m, 8, PPh: H_o), 7.20 (t, 4, PPh: H_p), 7.10 (t, 8, PPh: H_m), 6.65 (d, 4, NAr: H_m), 6.59 (d, 4, NAr: H_o), 3.52 (s, 3, OMe), 2.77 (s, 2, HH'CC(CO₂Me)CHH'), 2.03 (s, 6, NAr: Me), 2.03 or 1.81 (m, 1, PCHP), 1.72 (s, 2, HH'CC(CO₂Me)CHH'); ¹³C NMR (THF-*d*₈, selected resonances only) δ 50.9 and 47.9

30

35

($\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$), 19.5 (NAr: Me), 12.0 (t, $J_{\text{CP}} = 109$ Hz, PCHP).

Example 493

Complex **44a**. Two equiv (343 mg, 0.520 mmol) of the sodium salt of the ligand were reacted with one equiv (124 mg, 0.260 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 128 mg (32.8% yield) of an orange powder. The ^1H NMR spectrum is consistent with the presence of one major symmetrical isomer; some of the ligand is also present along with some impurities and possibly the presence of other isomers. (The three possible isomers include the isomer with both methyl groups anti to the CO_2Me group, the isomer with both methyl groups syn to the CO_2Me group, and the isomer with one Me group anti and one Me group syn to the CO_2Me group). The nonaromatic resonances of the major symmetrical isomer follow: ^1H NMR ($\text{THF-}d_8$) δ 3.60 (s, 3, OMe), 2.77 (s, 2, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$), 3.47 or 2.01 (m, 1, PCHP), 1.88 (s, 6, Ar: Me), 1.75 (s, 2, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$).

Example 494

Complex **45a**. Two equiv (349 mg, 2.10 mmol) of the lithium salt of the ligand were reacted with one equiv (500 mg, 1.05 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 255 mg (40.7% yield) of an brown-yellow powder. ^1H NMR ($\text{C}_6\text{D}_6/\text{THF-}d_8$) δ 6.02 (s, 1, Thiophene: H), 5.23 (s, 1, Thiophene: H), 3.78 (br s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 3.40 and 3.38 (s, 3 each, Thiophene: Me and CO_2Me), 2.41 (s, 2, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{C}'\text{HH}'$), 2.02 (s, 1, $\text{HH}'\text{CC}(\text{CO}_2\text{Me})\text{CHH}'$).

Example 495

Complex **46a**. Two equiv (587 mg, 2.11 mmol) of the lithium salt of the ligand were reacted with one equiv (501 mg, 1.05 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 765 mg (84.5% yield) of an orange powder. ^1H NMR spectrum in C_6D_6 is complex. Peaks consistent with two different isomers of the product are present.

Example 496

Complex **47a**. Two equiv (607 mg, 2.24 mmol) of the sodium salt of the ligand were reacted with one equiv (303 mg, 1.12 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl =
5 H_2CCHCH_2) to give 482 mg (61.8% yield) of a red powder.

Example 497

Complex **48a**. Two equiv (149 mg, 1.27 mmol) of the sodium salt of the ligand were reacted with one equiv (302 mg, 0.635 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl =
10 $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 146 mg (45.7% yield) of a red powder.

Example 498

Complex **49a**. Two equiv (700 mg, 2.17 mmol) of the sodium salt of the ligand were reacted with one equiv
15 (515 mg, 1.08 mmol) of $[(\text{allyl})\text{Ni}(\mu\text{-Br})]_2$ (allyl = $\text{H}_2\text{CC}(\text{CO}_2\text{Me})\text{CH}_2$) to give 779 mg (685.2% yield) of an orange powder. ^1H NMR spectrum in $\text{THF-}d_8$ is complex.

Examples 499-503

The following complexes of Examples through were
20 synthesized by mixing the protonated form of the hydroxy-imine ligand with a base (e.g., pyridine, lutidine, acetonitrile, etc.) in an Et_2O solution and cooling this solution to -35°C . The cold Et_2O solution was then added to a cold flask containing
25 $(\text{tmeda})\text{NiMe}_2$. [For the preparation of $(\text{tmeda})\text{NiMe}_2$ please see: Kaschube, W.; Porschke, K. R.; Wilke, G. J. *Organomet. Chem.* **1988**, 355, 525 - 532.] The reaction mixture was stirred for ~ 4 h. The solution was then filtered through a frit with dry Celite[®]. The
30 solvent was removed and the product was dried in vacuo.

Example 499

Complex **50**. One equiv of $[2-(\text{OH})-3,5-\text{Cl}_2-\text{C}_6\text{H}_2-\text{C}(\text{Me})=\text{NAr}]$ [$\text{Ar} = 2,6-(i\text{-Pr})_2-\text{C}_6\text{H}_3$] (356 mg, 0.976 mmol) was reacted with $(\text{tmeda})\text{NiMe}_2$ (200 mg, 0.976 mmol) and
35 pyridine (772 mg, 9.76 mmol) to yield an orange-red powder: ^1H NMR (C_6D_6) δ 8.66 (d, 2, Py: H_o), 7.50 (d, 1, Ar' : H), 7.31 (d, 1, Ar' : H), 7.09 (m, 3, Ar: H), 6.63 (t, 1, Py: H_p), 6.29 (t, 1, Py: H_m), 3.98 (septet,

2, CHMe₂), 1.68 (d, 6, CHMeMe'), 1.51 (s, 3, N=CMe), 1.04 (d, 6, CHMeMe'), -0.92 (s, 3, NiMe).

Example 500

Complex 51. One equiv of [2-(OH)-3,5-Cl₂-C₆H₂-
5 C(Me)=NAr [Ar = 2,6-(i-Pr)₂-C₆H₃] (88.8 mg, 0.244 mmol)
was reacted with (tmeda)NiMe₂ (50 mg, 0.244 mmol) and
lutidine (26.2 mg, 0.244 mmol) to yield an orange
powder: ¹H NMR (C₆D₆) δ 7.35 (d, 1, Ar': H), 7.28 (d,
1, Ar': H), 7.01 (s, 3, Ar: H), 6.64 (t, 1, Lutidine:
10 H_p), 6.28 (d, 2, Lutidine: H_m), 3.91 (septet, 2, CHMe₂),
3.72 (s, 6, Lutidine: Me), 1.52 (d, 6, CHMeMe'), 1.46
(s, 3, N=CMe), 0.98 (d, 6, CHMeMe'), -1.42 (s, 3,
NiMe).

Example 501

Complex 52. One equiv of [2-(OH)-3,5-Cl₂-C₆H₂-
15 C(Me)=NAr [Ar = 2,6-(i-Pr)₂-C₆H₃] (370 mg, 1.02 mmol)
was reacted with (tmeda)NiMe₂ (209 mg, 1.02 mmol) and
acetonitrile (10 mL) to yield a yellow-orange powder:
¹H NMR (CD₂Cl₂) δ 7.23 (d, 1, Ar': H), 7.10 (t, 1, Ar:
20 H_p), 7.04 (d, 2, Ar: H_m), 6.95 (d, 1, Ar': H), 4.34
(septet, 2, CHMe₂), 1.89 (s, 3, N=CMe), 1.70 (s, 3,
NC=Me), 1.33 (d, 6, CHMeMe'), 1.15 (d, 6, CHMeMe'),
0.80 (s, 3, NiMe).

Example 502

Complex 53. One equiv of [2-(OH)-3,5-Cl₂-C₆H₂-
25 C(Me)=NAr [Ar = 2,6-(i-Pr)₂-C₆H₃] (88.8 mg, 0.244 mmol)
was reacted with (tmeda)NiMe₂ (50 mg, 0.244 mmol) and
p-tolunitrile (28.6 mg, 0.244 mmol) to yield a brown
powder: ¹H NMR (CD₂Cl₂) δ 7.74 (d, 2, Nitrile: H),
30 7.23 (d, 1, Ar': H), 7.21 (d, 2, Nitrile: H), 7.10 (t,
1, Ar: H_p), 7.04 (d, 1, Ar: H_m), 6.95 (d, 1, Ar': H),
4.34 (septet, 2, CHMe₂), 2.33 (s, 3, Nitrile: Me), 1.70
(s, 3, N=CMe), 1.33 (d, 6, CHMeMe'), 1.15 (d, 6,
CHMeMe'), 0.80 (s, 3, NiMe).

35

Example 503

Complex 54. One equiv of [2-(OH)-3,5-Br₂-C₆H₂-
C(Me)=NAr [Ar = 2,6-(i-Pr)₂-C₆H₃] (111 mg, 0.244 mmol)
was reacted with (tmeda)NiMe₂ (50 mg, 0.244 mmol) and

pyridine (200 mg) to yield a yellow-orange powder: ¹H NMR (C₆D₆) δ 8.77 (d, 2, Py: H_o), 7.60 (t, 1, Py: H_p), 7.52 (d, 1, Ar': H), 7.44 (d, 1, Ar': H), 7.13 (t, 2, Py: H_m), 7.10 (s, 3, Ar: H), 3.85 (septet, 2, CHMe₂), 1.82 (s, 3, N=CMe), 1.51 (d, 6, CHMeMe'), 1.07 (d, 6, CHMeMe'), -1.42 (s, 3, NiMe).

Examples 504-509

General Procedure for Ethylene(28-35 kPa)/α-Olefin Copolymerizations of Table 19

10 In the drybox, a glass Schlenk flask was loaded with the nickel compound, Lewis acid, solvent, comonomer, and a stir bar. The flask was then capped with a rubber septum and the stopcock was closed prior to removing the flask from the drybox. The flask was
15 then attached to the ethylene line where it was evacuated and backfilled with ethylene. The reaction mixture was stirred under ethylene for the stated reaction time, the ethylene pressure was then released, and the polymer was precipitated by adding the reaction
20 mixture to a solution of MeOH (~100 mL) and concentrated HCl (~1-3 mL). The solid polymer was then collected on a frit and rinsed with MeOH. For amorphous polymers, the MeOH was decanted off of the polymer. Often, the amorphous polymer was dissolved in
25 hexane and reprecipitated in methanol. The polymer was transferred to a pre-weighed vial and dried under vacuum overnight. The polymer yield and characterization were then obtained.

For Example 505 the following quantitative ¹³C NMR (TCB, 120-140°C) was obtained: Branching per 1000
30 CH₂'s; total methyls (98.4), methyl (54.5), ethyl (13.1), propyl (3.2), butyl (14.4), amyl (4.9), hexyl and greater and end of chains (11.1), amyl and greater and end of chains (13.7), butyl and greater and end of
35 chains (27.6)

For Example 506 the following quantitative ¹³C NMR (TCB, 120-140°C) was obtained: Branching per 1000 CH₂'s; total methyls (115.4), methyl (61.5), ethyl

(12.8), propyl (3.8), butyl (21.3), amyl (4.0), hexyl and greater and end of chains (14.4), amyl and greater and end of chains (16.3), butyl and greater and end of chains (37.2)

5

Table 19.

<u>Ethylene/α-Olefin Copolymerizations at 28-35 kPa Ethylene</u>						
Ex.	Cmpd	Lewis Acid (equiv)	Time (h)	Toluene (mL)	Comonomer (mL)	Polymer (g)
504	3a	BPh ₃ /20	32	30	1-Hexene (10)	0.633
Description: Viscous clear oil. ¹ H NMR (C ₆ D ₆ , rt): 198.2 Total Me/1000 CH ₂						
505	6a	B(C ₆ F ₅) ₃ /20	24.2	30	1-Hexene (5)	7.31
Description: Tough, rubbery, amorphous light tan solid. ¹ H NMR (C ₆ D ₆ , rt): 116.1 Total Me/1000 CH ₂						
506	6a	B(C ₆ F ₅) ₃ /20	24.2	25	1-Hexene (10)	6.26
Description: Rubbery, slightly sticky amorphous light tan solid. ¹ H NMR (C ₆ D ₆ , rt): 129.9 Total Me/1000 CH ₂						
507	6a	B(C ₆ F ₅) ₃ /20	24.2	20	1-Hexene (15)	4.18
Description: Sticky, very viscous oil--almost a solid. ¹ H NMR (C ₆ D ₆ , rt): 167.9 Total Me/1000 CH ₂						
508	6a	B(C ₆ F ₅) ₃ /20	33.3	30	1-Octene (5)	5.65
Description: Tough, amorphous rubbery solid. ¹ H NMR (C ₆ D ₆ , rt): 112.0 Total Me/1000 CH ₂						
509	9a	B(C ₆ F ₅) ₃ /20	27.3	30	1-Octene (5)	7.53
Description: Sticky, amorphous light tan solid. ¹ H NMR (C ₆ D ₆ , rt): 178.7 Me/1000 CH ₂						

Examples 510-512General Procedure for Homopolymerizations of 1-Hexene, 1-Octene, and Cyclopentene by Cmpd 6a (Table 20)

10

15

In the drybox, the nickel compound, Lewis acid, solvent, monomer and stir bar were placed together in a round bottom flask. The reaction mixture was stirred for the stated amount of time. The flask was removed from the drybox and water and concentrated hydrochloric acid were added. The product was extracted with toluene and/or hexane and the solution was filtered through a frit containing a layer of neutral alumina on

top of a layer of silica gel. The solvent was then evaporated and the product was dried in vacuo.

Table 20

5

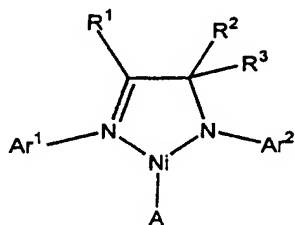
Ethylene/ α -Olefin Copolymerizations at 28-35 kPa Ethylene

Ex.	Cmpd	Lewis Acid (equiv)	Time (weeks)	Toluene (mL)	Comonomer (mL)	Polymer (g)
510	6a	B(C ₆ F ₅) ₃ /20	~2	5	1-Hexene (10)	0.511
Description: Viscous oil. ¹ H NMR (C ₆ D ₆ , rt): 152.2 Total Me per 1000 Carbon Atoms; DP ~ 17.4; M _n ~ 1,460						
511	6a	B(C ₆ F ₅) ₃ /20	~2	5	1-Octene (10)	1.83
Description: Free-flowing, slightly viscous oil. ¹ H NMR (C ₆ D ₆ , rt): 122.8 Total Me per 1000 Carbon Atoms; DP ~ 10.5; M _n ~ 1,180						
512	6a	B(C ₆ F ₅) ₃ /20	~2	5	Cyclopentene (10)	1.57
Description: Partial viscous oil/partial solid. ¹ H NMR (C ₆ D ₆) indicates polycyclopentene formation with olefinic end groups present.						

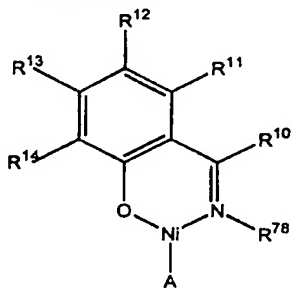
CLAIMS

What is claimed is:

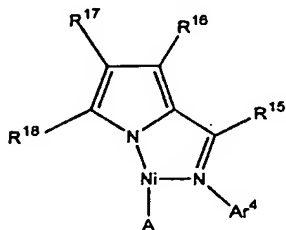
1. A process for the polymerization of an olefin selected from one or more of $R^{67}CH=CH_2$, cyclopentene, a styrene, a norbornene or $H_2C=CH(CH_2)_5CO_2R^{77}$, comprising, contacting, at a temperature of about $-100^\circ C$ to about $+200^\circ C$, $R^{67}CH=CH_2$, cyclopentene, a styrene, a norbornene, or $H_2C=CH(CH_2)_5CO_2R^{77}$, optionally a Lewis acid, and a compound of the formula:



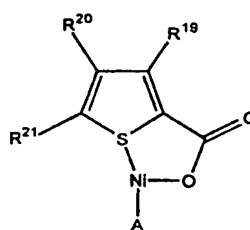
(I),



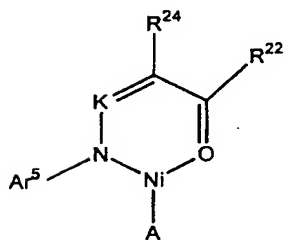
(II),



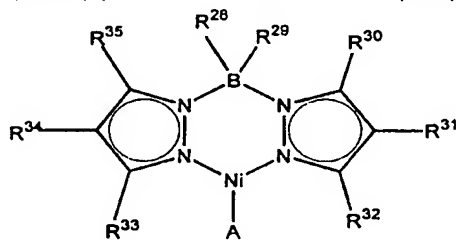
(III),



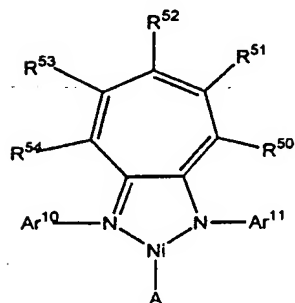
(IV),



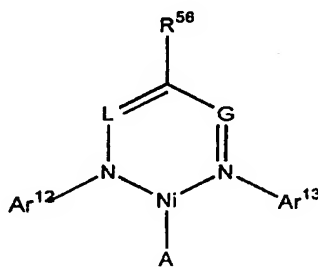
(V),



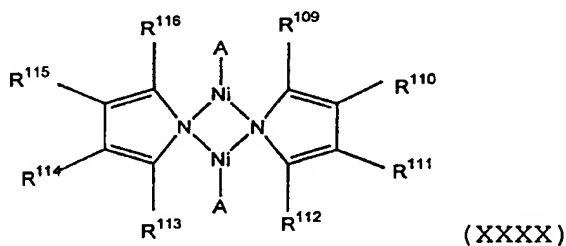
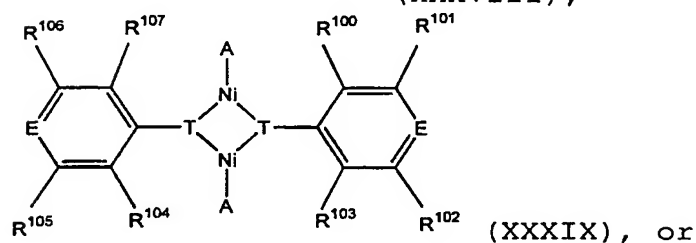
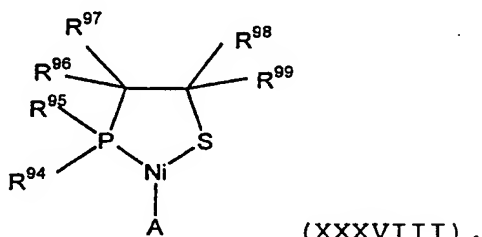
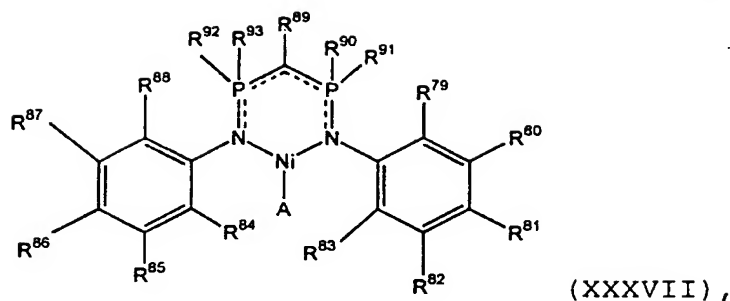
(VI),



(XVIII),



(XXVII)



wherein:

- Ar¹, Ar², Ar⁴, Ar⁵, Ar¹⁰, Ar¹¹, Ar¹² and Ar¹³
 10 are each independently aryl or substituted aryl;
 R¹ and R² are each independently hydrogen,
 hydrocarbyl, substituted hydrocarbyl, or R¹ and R²
 taken together form a ring, and R³ is hydrogen,
 hydrocarbyl or substituted hydrocarbyl or R¹, R² and R³
 15 taken together form a ring;
 A is a π -allyl or π -benzyl group;
 R¹⁰ and R¹⁵ are each independently hydrogen,
 hydrocarbyl or substituted hydrocarbyl;

$R^{11}, R^{12}, R^{13}, R^{14}, R^{16}, R^{17}, R^{18}, R^{19}, R^{20},$
 $R^{21}, R^{30}, R^{31}, R^{32}, R^{33}, R^{34}, R^{35}, R^{50}, R^{51}, R^{52}, R^{53}$

and R^{54} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, an inert functional group, and provided that any two of these groups vicinal to one another taken together may form a ring;

K is N or CR^{27} ;

R^{22} is hydrocarbyl, substituted hydrocarbyl, $-SR^{117}$, $-OR^{117}$, or $-NR^{118}_2$, R^{24} is hydrogen, a functional group, hydrocarbyl or substituted hydrocarbyl, and R^{27} is hydrocarbyl or substituted hydrocarbyl, and provided that R^{22} and R^{24} or R^{24} and R^{27} taken together may form a ring;

R^{117} is hydrocarbyl or substituted hydrocarbyl; each R^{118} is independently hydrogen, hydrocarbyl or substituted hydrocarbyl;

G and L are both N or G is CR^{57} and L is CR^{55} ; R^{55} , R^{56} and R^{57} are each independently hydrogen, hydrocarbyl or substituted hydrocarbyl, or any two of R^{55} , R^{56} and R^{57} taken together form a ring;

R^{67} is hydrogen, alkyl or substituted alkyl; R^{77} is hydrocarbyl or substituted hydrocarbyl; R^{78} is hydrocarbyl or substituted hydrocarbyl; R^{79} , R^{80} , R^{81} , R^{82} , R^{83} , R^{84} , R^{85} , R^{86} , R^{87} , R^{88} and

R^{89} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or a functional group;

R^{90} , R^{91} , R^{92} and R^{93} are each independently hydrocarbyl or substituted hydrocarbyl;

R^{94} and R^{95} are each independently hydrocarbyl or substituted hydrocarbyl;

R^{96} , R^{97} , R^{98} , and R^{99} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group;

both of T are S (sulfur) or NH (amino);

each E is N (nitrogen) or CR^{108} wherein R^{108} is hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group;

R^{100} , R^{101} , R^{102} , R^{103} , R^{104} , R^{105} , R^{106} , and R^{107} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or a functional group;

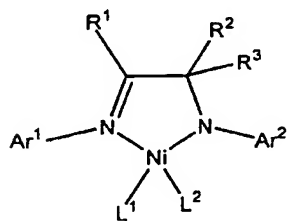
R^{109} , R^{110} , R^{111} , R^{112} , R^{113} , R^{114} , R^{115} and R^{116} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group;

s is an integer of 1 or more; and

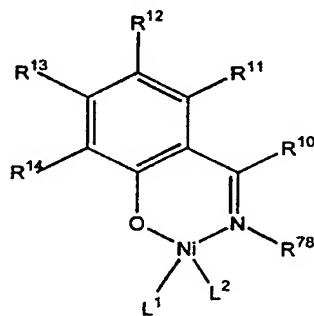
R^{28} and R^{29} are each independently hydrogen, hydrocarbyl or substituted hydrocarbyl;

and provided that when $H_2C=CH(CH_2)_sCO_2R^{77}$ is present, $R^{67}CH=CH_2$ is also present.

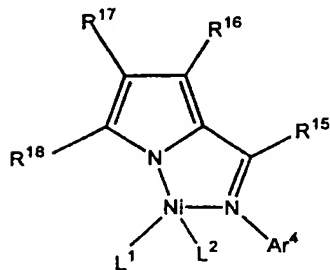
2. A process for the polymerization of an olefin selected from one or more of $R^{67}CH=CH_2$, a styrene, a norbornene or $H_2C=CH(CH_2)_sCO_2R^{77}$, comprising, contacting, at a temperature of about $-100^\circ C$ to about $+200^\circ C$, $R^{67}CH=CH_2$, cyclopentene, a styrene, a norbornene, or $H_2C=CH(CH_2)_sCO_2R^{77}$, optionally a Lewis acid, and a compound of the formula:



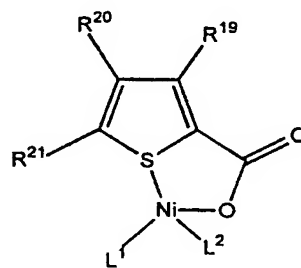
(VII),



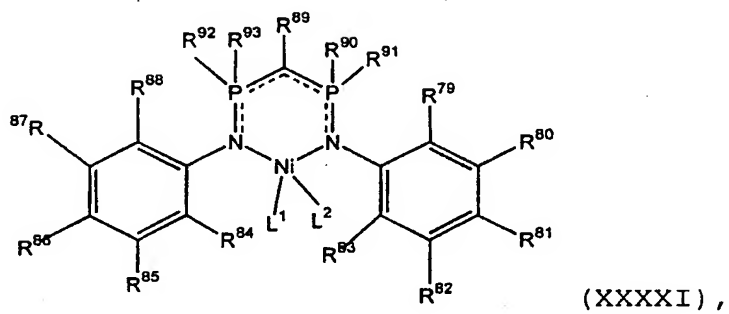
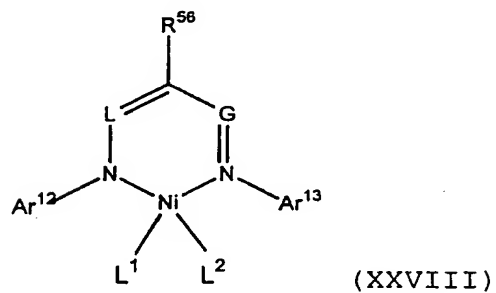
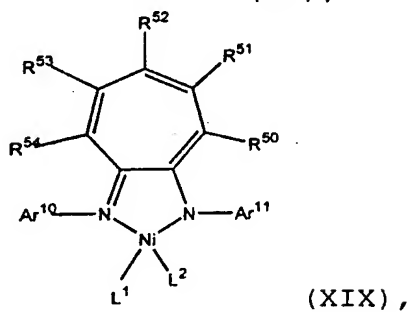
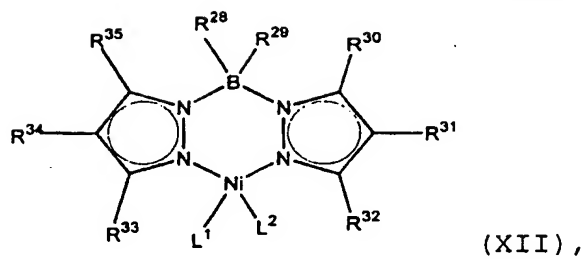
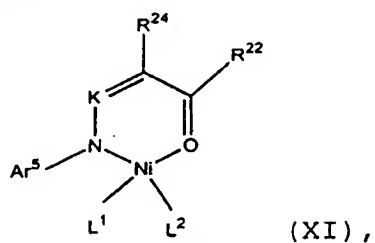
(VIII),



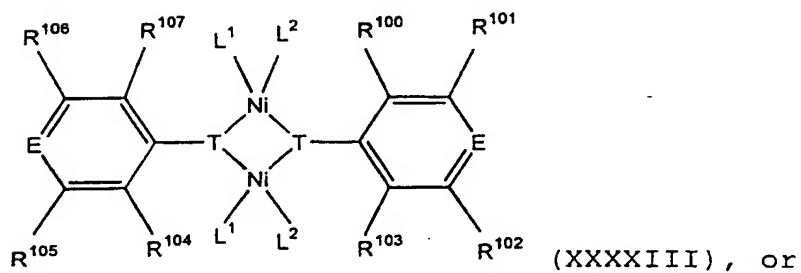
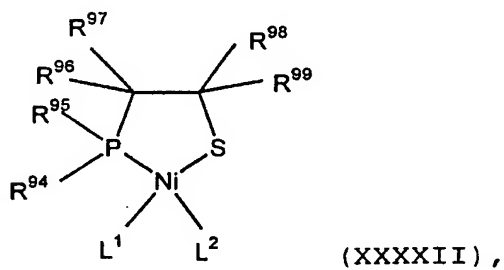
(IX),

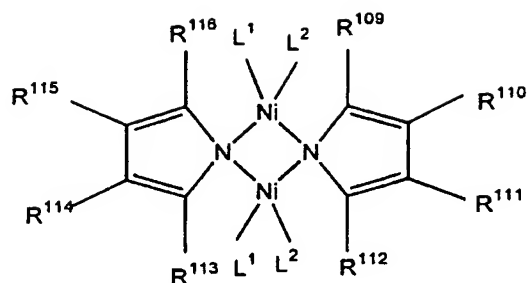


(X),



5





(XXXXIV),

wherein:

L^1 is a neutral monodentate ligand which may be displaced by said olefin, and L^2 is a monoanionic monodentate ligand, or L^1 and L^2 taken together are a monoanionic bidentate ligand, provided that said monoanionic monodentate ligand or said monoanionic bidentate ligand may add to said olefin;

Ar^1 , Ar^2 , Ar^4 , Ar^5 , Ar^{10} , Ar^{11} , Ar^{12} and Ar^{13} are each independently aryl or substituted aryl;

R^1 and R^2 are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or R^1 and R^2 taken together form a ring, and R^3 is hydrogen, hydrocarbyl or substituted hydrocarbyl or R^1 , R^2 and R^3 taken together form a ring;

R^{10} and R^{15} are each independently hydrogen, hydrocarbyl or substituted hydrocarbyl;

R^{11} , R^{12} , R^{13} , R^{14} , R^{16} , R^{17} , R^{18} , R^{19} , R^{20} , R^{21} , R^{30} , R^{31} , R^{32} , R^{33} , R^{34} , R^{35} , R^{50} , R^{51} , R^{52} , R^{53} and R^{54} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, an inert functional group, and provided that any two of these groups vicinal to one another taken together may form a ring;

K is N or CR^{27} ;

R^{22} is hydrocarbyl, substituted hydrocarbyl, $-SR^{117}$, $-OR^{117}$, or $-NR^{118}_2$, R^{24} is hydrogen, a functional group, hydrocarbyl or substituted hydrocarbyl, and R^{27} is hydrocarbyl or substituted hydrocarbyl, and provided that R^{22} and R^{24} or R^{24} and R^{27} taken together may form a ring;

R^{117} is hydrocarbyl or substituted hydrocarbyl;

each R^{118} is independently hydrogen, hydrocarbyl or substituted hydrocarbyl;

G and L are both N or G is CR^{57} and L is CR^{55} ;
 R^{55} , R^{56} and R^{57} are each independently

5 hydrogen, hydrocarbyl or substituted hydrocarbyl, or any two of R^{55} , R^{56} and R^{57} taken together form a ring;

R^{67} is hydrogen, alkyl or substituted alkyl;

R^{77} is hydrocarbyl or substituted hydrocarbyl;

R^{78} is hydrocarbyl or substituted hydrocarbyl;

10 R^{79} , R^{80} , R^{81} , R^{82} , R^{83} , R^{84} , R^{85} , R^{86} , R^{87} , R^{88} and R^{89} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or a functional group;

R^{90} , R^{91} , R^{92} and R^{93} are each independently hydrocarbyl or substituted hydrocarbyl;

15 R^{94} and R^{95} are each independently hydrocarbyl or substituted hydrocarbyl;

R^{96} , R^{97} , R^{98} , and R^{99} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group;

20 both of T are S (sulfur) or NH (amino);

each E is N (nitrogen) or CR^{108} wherein R^{108} is hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group;

R^{100} , R^{101} , R^{102} , R^{103} , R^{104} , R^{105} , R^{106} , and R^{107} are
25 each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or a functional group;

R^{109} , R^{110} , R^{111} , R^{112} , R^{113} , R^{114} , R^{115} and R^{116} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group;

30 s is an integer of 1 or more; and

R^{28} and R^{29} are each independently hydrogen, hydrocarbyl or substituted hydrocarbyl;

and provided that when $H_2C=CH(CH_2)_sCO_2R^{77}$ is present, $R^{67}CH=CH_2$ is also present.

35 3. The process as recited in claim 1 or 2 wherein said temperature is about 0°C to about 150°C.

4. The process as recited in claim 1 or 2 wherein said temperature is about 25°C to about 100°C.

5. The process as recited in claim 1 or 2 wherein said Lewis acid is present.

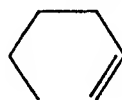
6. The process as recited in claim 1 or 2 wherein said Lewis acid is not present.

7. The process as recited in claim 1 or 2 wherein said compound is (I) or (VII).

8. The process as recited in claim 7 wherein:

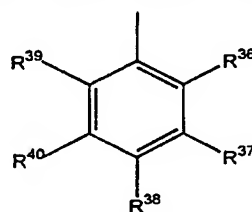
R^1 and R^2 are both hydrogen;

R^3 is alkyl or aryl containing 1 to 20 carbon atoms, or R^1 , R^2 and R^3 taken together are



; and

Ar^1 and Ar^2 are each independently



(XIV)

wherein R^{36} , R^{37} , R^{38} , R^{39} and R^{40} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group, provided that any 2 of R^{36} , R^{37} , R^{38} , R^{39} and R^{40} that are vicinal to one another taken together may form a ring.

9. The process as recited in claim 8 wherein R^3 is t-butyl, R^1 and R^2 are hydrogen, and R^{36} and R^{39} are halo, phenyl, or alkyl containing 1 to 6 carbon atoms.

10. The process as recited in claim 1 or 2 wherein said compound is (II) or (VIII).

11. The process as recited in claim 10 wherein:

R^{10} is hydrogen or methyl;

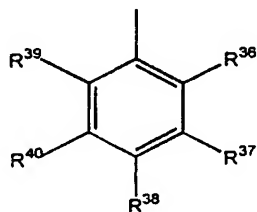
R^{78} is Ar^3 , which is aryl or substituted aryl;

and

R^{11} , R^{12} , R^{13} and R^{14} are each independently chloro, bromo, iodo, alkyl, alkoxy, hydrogen or nitro, or R^{11} and R^{12} taken together form a 6-membered carbocyclic ring and R^{13} and R^{14} are hydrogen.

12. The process as recited in claim 1 or 2 wherein said compound is (III) or (IX).

13. The process as recited in claim 12 wherein:
 R^{15} , R^{16} , R^{17} and R^{18} are hydrogen; and
 Ar^4 is



(XIV)

wherein R^{36} , R^{37} , R^{38} , R^{39} and R^{40} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group, provided that any 2 of R^{36} , R^{37} , R^{38} , R^{39} and R^{40} that are vicinal to one another taken together may form a ring.

14. The process as recited in claim 1 or 2 wherein said compound is (IV) or (X).

15. The process as recited in claim 14 wherein R^{19} , R^{20} and R^{21} are hydrogen, or R^{19} and R^{20} are hydrogen and R^{21} is methyl.

16. The process as recited in claim 1 or 2 wherein said compound is (V) or (XI).

17. The process as recited in claim 16 wherein:
 K is CR^{27} ;
 R^{27} is hydrogen, hydrocarbyl, substituted hydrocarbyl, or a functional group;
 R^{24} is hydrogen, alkyl or halo;
 R^{22} is hydrocarbyl or $-OR^{117}$, wherein R^{117} is hydrocarbyl.

18. The process as recited in claim 17 wherein:
 R^{27} is methyl;
 R^{22} is phenyl, or $-OR^{117}$, R^{117} is alkyl containing 1 to 6 carbon atoms; and
 R^{24} is hydrogen.

19. The process as recited in claim 1 or 2 wherein said compound is (VI) or (XII).

20. The process as recited in claim 19 wherein:

R^{32} and R^{33} are both alkyl containing 1 to 6 carbon atoms or phenyl, more preferably isopropyl, R^{28} and R^{29} are both hydrogen or phenyl, and R^{30} , R^{31} , R^{34} and R^{35} are all hydrogen; or

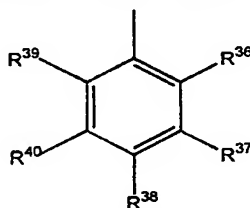
R^{31} and R^{32} taken together and R^{33} and R^{34} taken together are both a 6-membered aromatic carbocyclic ring having a t-butyl group vicinal to the R^{32} and R^{33} positions, and R^{28} and R^{29} are both hydrogen.

21. The process as recited in claim 1 or 2 wherein said compound is (XVIII) or (XIX).

22. The process as recited in claim 21 wherein:

R^{50} , R^{51} , R^{52} , R^{53} and R^{54} are hydrogen; and

Ar^{10} and Ar^{11} are each independently



(XIV)

wherein R^{36} , R^{37} , R^{38} , R^{39} and R^{40} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group, provided that any 2 of R^{36} , R^{37} , R^{38} , R^{39} and R^{40} that are vicinal to one another taken together may form a ring.

23. The process as recited in claim 1 or 2 wherein said compound is (XXVII) or (XXVIII).

24. The process as recited in claim 23 wherein:

L is CR^{55} ;

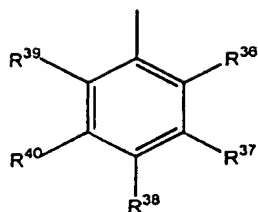
R^{55} is hydrocarbyl, hydrogen, or substituted hydrocarbyl;

G is CR^{57} ;

R^{57} is hydrocarbyl, hydrogen or substituted hydrocarbyl;

R^{56} is hydrogen; and

Ar^{12} and Ar^{13} are each independently



(XIV)

wherein R^{36} , R^{37} , R^{38} , R^{39} and R^{40} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group, provided that any 2 of R^{36} , R^{37} , R^{38} , R^{39} and R^{40} that are vicinal to one another taken together may form a ring.

25. The process as recited in claim 24 wherein R^{55} and R^{57} are both alkyl or fluorinated alkyl, and Ar^{12} and Ar^{13} are both 2,6-diisopropylphenyl.

26. The process as described in claim 1 or 2 wherein said compound is (XXXVII) or (XXXI).

27. The process as recited in claim 26 wherein:
 R^{79} , R^{80} , R^{81} , R^{82} , R^{83} , R^{84} , R^{85} , R^{86} , R^{87} , R^{88}
 and R^{89} are each independently hydrogen or alkyl; and
 R^{90} , R^{91} , R^{92} and R^{93} are each independently hydrocarbyl.

28. The process as described in claim 1 or 2 wherein said compound is (XXXVIII) or (XXXII).

29. The process as recited in claim 28 wherein:
 R^{94} and R^{95} are each independently hydrocarbyl; and
 R^{96} , R^{97} , R^{98} , and R^{99} are each independently hydrogen or hydrocarbyl.

30. The process as recited in claim 1 or 2 wherein said compound is (XXXIX) or (XXXIII).

31. The process as recited in claim 30 wherein:
 E is N or CR^{108} ;
 R^{108} is hydrogen or hydrocarbyl; and
 R^{100} , R^{101} , R^{102} , R^{103} , R^{104} , R^{105} , R^{106} , and R^{107} are each independently hydrogen, hydrocarbyl, or halo.

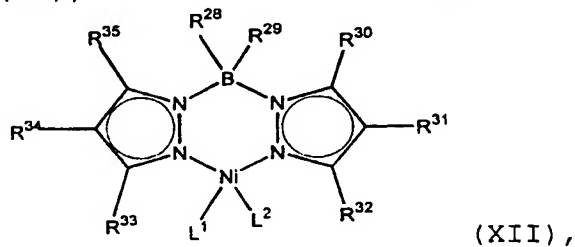
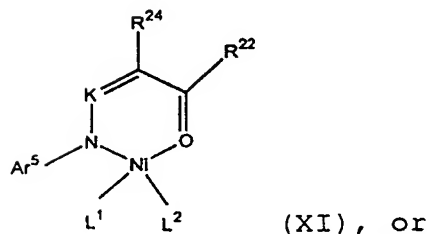
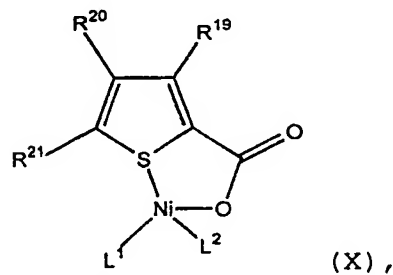
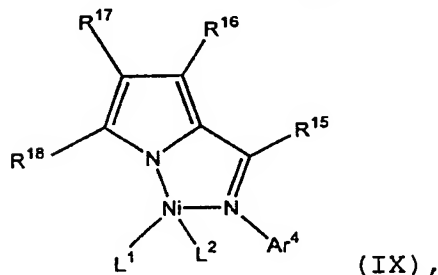
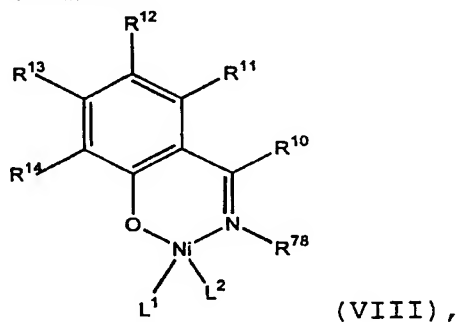
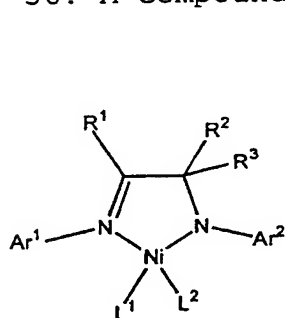
32. The process as recited in claim 1 or 2 wherein said compound is (XXXX) or (XXXXIV).

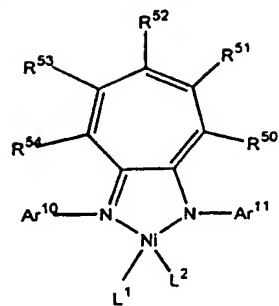
33. The process as recited in claim 32 wherein R^{109} , R^{110} , R^{111} , R^{112} , R^{113} , R^{114} , R^{115} and R^{116} are each independently hydrogen or hydrocarbyl.

34. The process as recited in claim 2 wherein L^1 is a nitrile, pyridine or substituted pyridine, and L^2 is methyl.

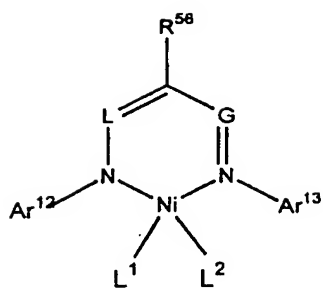
35. The process as recited in claim 1 or claim 2 wherein said olefin or olefins are: ethylene; a styrene; a norbornene; an α -olefin; cyclopentene; $H_2C=CH(CH_2)_sCO_2R^{77}$ and ethylene; ethylene and an α -olefin; a styrene and a norbornene; and 2 or more norbornenes.

36. A compound of the formula:

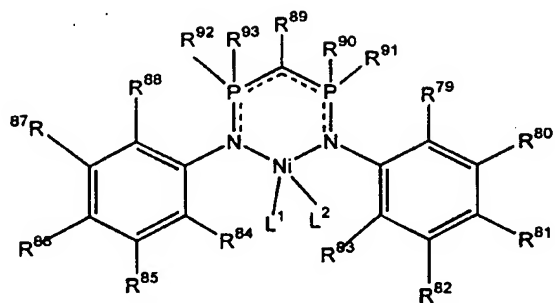




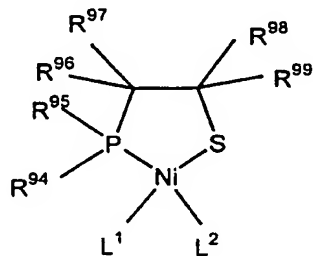
(XIX),



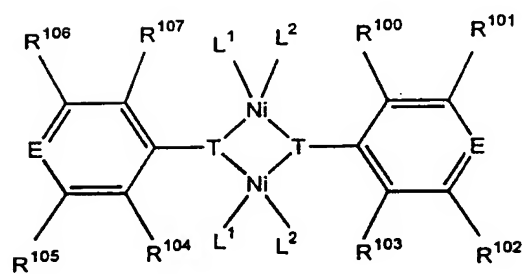
(XXVIII)



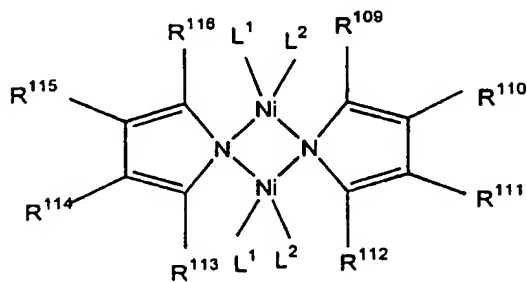
(XXXXI),



(XXXXII),



(XXXXIII), or



(XXXXIV),

wherein:

L^1 is a neutral monodentate ligand which may be displaced by said olefin, and L^2 is a monoanionic monodentate ligand, or L^1 and L^2 taken together are a
5 monoanionic bidentate ligand, provided that said monoanionic monodentate ligand or said monoanionic bidentate ligand may add to said olefin;

$Ar^1, Ar^2, Ar^4, Ar^5, Ar^{10}, Ar^{11}, Ar^{12}$ and Ar^{13} are each independently aryl or substituted aryl;
10 R^1 and R^2 are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or R^1 and R^2 taken together form a ring, and R^3 is hydrogen, hydrocarbyl or substituted hydrocarbyl or R^1, R^2 and R^3 taken together form a ring;

15 R^{10} and R^{15} are each independently hydrogen, hydrocarbyl or substituted hydrocarbyl;
 $R^{11}, R^{12}, R^{13}, R^{14}, R^{16}, R^{17}, R^{18}, R^{19}, R^{20}, R^{21}, R^{30}, R^{31}, R^{32}, R^{33}, R^{34}, R^{35}, R^{50}, R^{51}, R^{52}, R^{53}$ and R^{54} are each independently hydrogen, hydrocarbyl,
20 substituted hydrocarbyl, an inert functional group, and provided that any two of these groups vicinal to one another taken together may form a ring;

K is N or CR^{27} ;
 R^{22} is hydrocarbyl, substituted hydrocarbyl,
25 $-SR^{117}, -OR^{117}$, or $-NR^{118}$, R^{24} is hydrogen, a functional group, hydrocarbyl or substituted hydrocarbyl, and R^{27} is hydrocarbyl or substituted hydrocarbyl, and provided that R^{22} and R^{24} or R^{24} and R^{27} taken together may form a ring;

30 R^{117} is hydrocarbyl or substituted hydrocarbyl;
each R^{118} is independently hydrogen, hydrocarbyl or substituted hydrocarbyl;

G and L are both N or G is CR^{57} and L is CR^{55} ;
 R^{55}, R^{56} and R^{57} are each independently
35 hydrogen, hydrocarbyl or substituted hydrocarbyl, or any two of R^{55}, R^{56} and R^{57} taken together form a ring;
 R^{78} is hydrocarbyl or substituted hydrocarbyl;

R^{79} , R^{80} , R^{81} , R^{82} , R^{83} , R^{84} , R^{85} , R^{86} , R^{87} , R^{88} and R^{89} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or a functional group;

R^{90} , R^{91} , R^{92} and R^{93} are each independently hydrocarbyl or substituted hydrocarbyl;

R^{94} and R^{95} are each independently hydrocarbyl or substituted hydrocarbyl;

R^{96} , R^{97} , R^{98} , and R^{99} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group;

both of T are S (sulfur) or NH (amino);

each E is N (nitrogen) or CR^{108} wherein R^{108} is hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group;

R^{100} , R^{101} , R^{102} , R^{103} , R^{104} , R^{105} , R^{106} , and R^{107} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or a functional group;

R^{109} , R^{110} , R^{111} , R^{112} , R^{113} , R^{114} , R^{115} and R^{116} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group; and

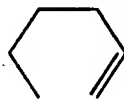
R^{28} and R^{29} are each independently hydrogen, hydrocarbyl or substituted hydrocarbyl.

37. The compound as recited in claim 36 which is (I) or (VII).

38. The compound as recited in claim 37 wherein:

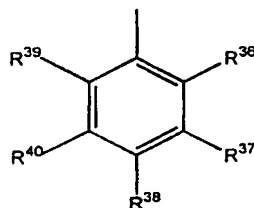
R^1 and R^2 are both hydrogen;

R^3 is alkyl or aryl containing 1 to 20 carbon atoms, or R^1 , R^2 and R^3 taken together are



; and

Ar^1 and Ar^2 are each independently



(XIV)

wherein R^{36} , R^{37} , R^{38} , R^{39} and R^{40} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group, provided that any 2 of R^{36} , R^{37} , R^{38} , R^{39} and R^{40} that are vicinal to one another taken together may form a ring.

39. The compound as recited in claim 38 wherein R^3 is t-butyl, R^1 and R^2 are hydrogen, and R^{36} and R^{39} are halo, phenyl, or alkyl containing 1 to 6 carbon atoms.

40. The compound as recited in claim 36 which is (II) or (VIII).

41. The compound as recited in claim 40 wherein:

R^{10} is hydrogen or methyl;

R^{78} is Ar^3 , which is aryl or substituted aryl;

and

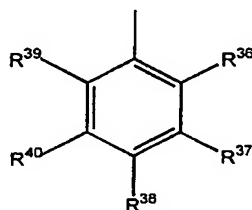
R^{11} , R^{12} , R^{13} and R^{14} are each independently chloro, bromo, iodo, alkyl, alkoxy, hydrogen or nitro, or R^{11} and R^{12} taken together form a 6-membered carbocyclic ring and R^{13} and R^{14} are hydrogen.

42. The compound as recited in claim 36 which is (III) or (IX).

43. The compound as recited in claim 42 wherein:

R^{15} , R^{16} , R^{17} and R^{18} are hydrogen; and

Ar^4 is



(XIV)

wherein R^{36} , R^{37} , R^{38} , R^{39} and R^{40} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group, provided that any 2 of R^{36} , R^{37} , R^{38} , R^{39} and R^{40} that are vicinal to one another taken together may form a ring.

44. The compound as recited in claim 36 which is (IV) or (X).

45. The compound as recited in claim 44 wherein R^{19} , R^{20} and R^{21} are hydrogen, or R^{19} and R^{20} are hydrogen and R^{21} is methyl.

46. The compound as recited in claim 36 which is (V) or (XI).

47. The compound as recited in claim 46 wherein:

K is CR²⁷;

R²⁷ is hydrogen, hydrocarbyl, substituted hydrocarbyl, or a functional group;

R²⁴ is hydrogen, alkyl or halo;

R²² is hydrocarbyl or -OR¹¹⁷, wherein R¹¹⁷ is hydrocarbyl.

48. The compound as recited in claim 47 wherein:

R²⁷ is methyl;

R²² is phenyl, or -OR¹¹⁷, R¹¹⁷ is alkyl containing 1 to 6 carbon atoms; and

R²⁴ is hydrogen.

49. The compound as recited in claim 36 which is (VI) or (XII).

50. The compound as recited in claim 49 wherein:

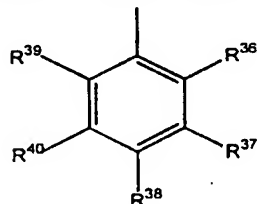
R³² and R³³ are both alkyl containing 1 to 6 carbon atoms or phenyl, more preferably isopropyl, R²⁸ and R²⁹ are both hydrogen or phenyl, and R³⁰, R³¹, R³⁴ and R³⁵ are all hydrogen; or

R³¹ and R³² taken together and R³³ and R³⁴ taken together are both a 6-membered aromatic carbocyclic ring having a t-butyl group vicinal to the R³² and R³³ positions, and R²⁸ and R²⁹ are both hydrogen.

51. The compound as recited in claim 36 which is (XVIII) or (XIX).

52. The compound as recited in claim 51 wherein:

R⁵⁰, R⁵¹, R⁵², R⁵³ and R⁵⁴ are hydrogen; and Ar¹⁰ and Ar¹¹ are each independently



(XIV)

wherein R³⁶, R³⁷, R³⁸, R³⁹ and R⁴⁰ are each independently hydrogen, hydrocarbyl, substituted

hydrocarbyl or a functional group, provided that any 2 of R^{36} , R^{37} , R^{38} , R^{39} and R^{40} that are vicinal to one another taken together may form a ring.

53. The compound as recited in claim 36 which is
 5 (XXVII) or (XXVIII).

54. The compound as recited in claim 53 wherein:

L is CR^{55} ;

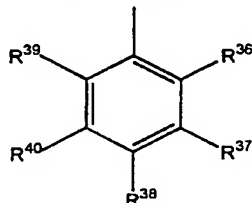
R^{55} is hydrocarbyl, hydrogen, or substituted hydrocarbyl;

10 G is CR^{57} ;

R^{57} is hydrocarbyl, hydrogen or substituted hydrocarbyl;

R^{56} is hydrogen; and

Ar^{12} and Ar^{13} are each independently



(XIV)

15 wherein R^{36} , R^{37} , R^{38} , R^{39} and R^{40} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group, provided that any 2 of R^{36} , R^{37} , R^{38} , R^{39} and R^{40} that are vicinal to one
 20 another taken together may form a ring.

55. The compound as recited in claim 54 wherein R^{55} and R^{57} are both alkyl or fluorinated alkyl, and Ar^{12} and Ar^{13} are both 2,6-diisopropylphenyl.

56. The compound as described in claim 36 which is
 25 (XXXVII) or (XXXI).

57. The compound as recited in claim 56 wherein:

R^{79} , R^{80} , R^{81} , R^{82} , R^{83} , R^{84} , R^{85} , R^{86} , R^{87} , R^{88} and R^{89} are each independently hydrogen or alkyl; and

R^{90} , R^{91} , R^{92} and R^{93} are each independently
 30 hydrocarbyl.

58. The compound as described in claim 36 which is (XXXVIII) or (XXXII).

59. The compound as recited in claim 58 wherein:

R^{94} and R^{95} are each independently hydrocarbyl; and

R^{96} , R^{97} , R^{98} , and R^{99} are each independently hydrogen or hydrocarbyl.

5 60. The compound as recited in claim 36 which is (XXXIX) or (XXXXIII).

61. The compound as recited in claim 60 wherein:

E is N or CR^{108} ;

R^{108} is hydrogen or hydrocarbyl; and

10 R^{100} , R^{101} , R^{102} , R^{103} , R^{104} , R^{105} , R^{106} , and R^{107} are each independently hydrogen, hydrocarbyl, or halo.

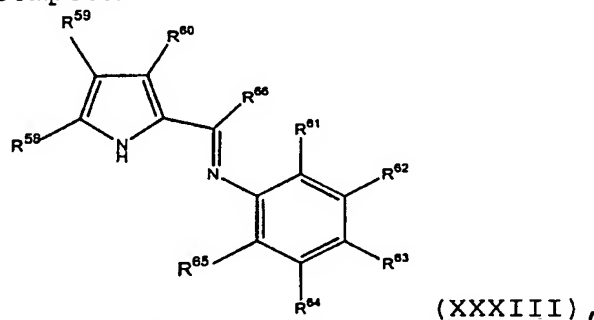
62. The compound as recited in claim 36 which is (XXXX) or (XXXXIV).

63. The compound as recited in claim 62 wherein
15 R^{109} , R^{110} , R^{111} , R^{112} , R^{113} , R^{114} , R^{115} and R^{116} are each independently hydrogen or hydrocarbyl.

64. The compound as recited in claim 36 wherein L^1 is a nitrile, pyridine, or a substituted pyridine, and L^2 is methyl.

20 65. The compound as recited in claim 36 wherein L^1 and L^2 taken together are not π -allyl or π -benzyl.

66. A compound of the formula



wherein:

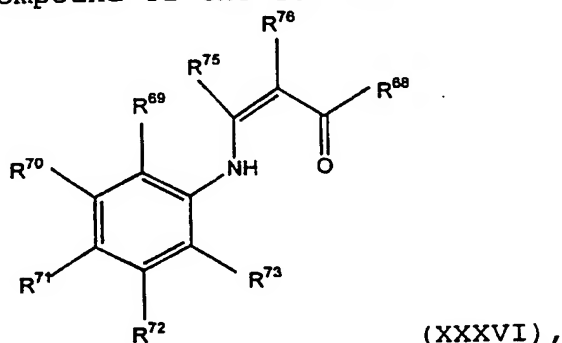
25 R^{58} , R^{59} , R^{60} , R^{62} , R^{63} and R^{64} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or a functional group, and provided that any two of these groups vicinal to one another taken together may form a ring, or if vicinal to R^{61} or R^{65}
30 form a ring with them;

R^{66} is hydrogen, hydrocarbyl or substituted hydrocarbyl; and

R^{61} and R^{65} are each independently hydrocarbyl containing 2 or more carbon atoms, or substituted hydrocarbyl containing 2 or more carbon atoms, and provided that R^{61} and R^{65} may form a ring with any group vicinal to it.

67. The compound as recited in claim 66 wherein;
 R^{58} , R^{59} , and R^{60} are hydrogen;
 R^{66} is hydrogen;
 R^{61} and R^{65} are each independently alkyl containing 2 or more carbon atoms; and
 R^{62} , R^{63} and R^{64} are hydrogen.

68. A compound of the formula



wherein:

R^{68} is hydrocarbyl, substituted hydrocarbyl, $-SR^{117}$, $-OR^{117}$, or $-NR^{118}_2$, R^{76} is hydrogen, a functional group, hydrocarbyl or substituted hydrocarbyl, and R^{75} is hydrocarbyl or substituted hydrocarbyl, and provided that R^{68} and R^{76} or R^{75} and R^{76} taken together may form a ring;

R^{117} is hydrocarbyl or substituted hydrocarbyl;
each R^{118} is independently hydrogen, hydrocarbyl or substituted hydrocarbyl;
 R^{70} , R^{71} and R^{72} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group;

R^{69} and R^{73} are hydrocarbyl containing 3 or more carbon atoms, substituted hydrocarbyl containing 3 or more carbon atoms or a functional group;

and provided that any two of R⁷⁰, R⁷¹, R⁷², R⁶⁹ and R⁷³ vicinal to one another together may form a ring.

69. The compound as recited in claim 68 wherein:

5 R⁶⁸ is -OR¹¹⁷ or aryl;

 R⁷⁵ is hydrocarbyl or substituted hydrocarbyl; and

 R⁷⁶ is hydrogen, hydrocarbyl, substituted hydrocarbyl or a functional group.

10 70. The compound as recited in claim 69 wherein R⁷⁶ is hydrogen, hydrocarbyl or substituted hydrocarbyl.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/00610

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C08F10/00 C08F4/70 C08F4/82 C07F15/04 C07D207/335
C07C225/14 C07C229/30 C07C237/16 C07C327/44

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C08F C07F C07D C07C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 96 23010 A (DU PONT; UNIV NORTH CAROLINA (US)) 1 August 1996 see claims ---	1-65
A	DE 44 15 725 A (ECOLE EUROP DES HAUTES ETUDES) 10 November 1994 see claims ---	1-65
A	US 5 395 811 A (NOVAK BRUCE ET AL) 7 March 1995 see claims and figures 1A and 1B -----	1-65

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

8 May 1998

Date of mailing of the international search report

25/05/1998

Name and mailing address of the ISA
European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Mergoni, M

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 98/00610

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9623010 A	01-08-96	AU 5020896 A	14-08-96
		CA 2211108 A	01-08-96
		CZ 9702351 A	17-12-97
		EP 0805826 A	12-11-97
		FI 973096 A	23-09-97
		NO 973310 A	23-09-97
		PL 322446 A	02-02-98
DE 4415725 A	10-11-94	FR 2704859 A	10-11-94
US 5395811 A	07-03-95	AU 1178295 A	06-06-95
		WO 9514046 A	26-05-95
		US 5525688 A	11-06-96

THIS PAGE BLANK (USPTO)